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REPORTS

ON

EXPERIMENTS ON THE MANURING OF TURNIPS AND ON SOME EXPERIMENTS WITH FARMYARD MANURE;

ON AN INVESTIGATION INTO GROWTH OF A DOUGLAS FIR PLANTATION;

ON GENERAL RECOMMENDATIONS AND SUGGESTIONS FOR CONDUCTING SCHOOL GARDENS;

ON MANURES: THEIR COMPOSITION, VALUATION, &c.;

ON THE WEATHER AT KILMARNOCK, 1911-1912; AND

ON POULTRY KEEPING AS PRACTISED AT THE POULTRY DEPARTMENT.

ELEVENTH AND TWELFTH ANNUAL REPORT.

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GLASGOW, 1914.

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NOTE OF ACKNOWLEDGMENT.

The Governors of the College have pleasure in expressing their indebtedness to the occupants of the many farms named in the subjoined Tables, who gave sections of their land free of charge for the purpose of the experiments, and who incurred much trouble, and not a little expense, in their careful supervision and execution.

They desire also to acknowledge their indebtedness to County Council Committees, to Local Committees, to Agricultural Associations, and to a large number of gentlemen who have freely assisted in the arrangement and execution of the experiments, and who have given donations of seeds and manures.

NOTE ON THE COST OF THE MANURES USED IN THE EXPERIMENTS.

The prices of the manures employed in all the experiments on which the calculations in the several Tables are based are those for which the manures could be purchased in Glasgow in the respective springs of the years in which the manures were applied by farmers paying cash, with the addition of 10s. per ton to cover costs of carriage and of application.

Bulletin No. 59.

West of Scotland Agricultural College,
GLASGOW.

REPORT

ON AN

Investigation into the current Annual Increment in Girth, at 5 feet above ground, of a Douglas Fir Plantation, 32 years of age, in the Quarries Wood on the Benmore Estate, Kilmun, Cowal District of Argyllshire, during the year 1911.

BY

J. NISBET, D.Œc.

Professor of Forestry.

GLASGOW, 1912.

Report on an Investigation into the current Annual Increment in Girth, at 5 feet above ground, of a Douglas Fir Plantation, 32 years of age, in the Quarries Wood on the Benmore Estate, Kilmun, Cowal District of Argyllshire during the year 1911.

Mr. YOUNGER of Benmore having kindly given permission for the selection of a sample plot of nearly pure Douglas Fir, planted in the spring of 1879, to be ring-banded and kept under continuous observation, year by year, to ascertain the current rate of growth in girth (measured at 5 feet above the ground), a plot of 2 square chains (22 yards by 44 yards = 968 square yards, or one-fifth of an acre) was selected and demarcated on 4th March, 1911. Owing to delay in obtaining the lead bands, the ring-banding of the stems and their original girth-measurement did not take place till 1st May, 1911—by which time, however, it is improbable that active vegetation had begun for the growing-period of 1911. The measurement of the year's growth took place on 17th February, 1912.

The sample plot selected, of 1 chain in width at base and extending for 2 chains up the hill-side, is at an elevation of about 500 feet above sea-level, and is on a steep hill-side with an eastern exposure; and it is situated in that part of the Benmore Quarries Wood which was planted in the spring of 1879, so that when ring-banded on 1st May, 1911, the plantation was 32 years old from date of planting. At the time of planting, the ground was described as steep, undulating, and rocky, and the surface-soil as sandy peat, with heather on the ridges and the tops of rocks, while the intervening hollows were of an open sandy and gravelly nature, and covered with brackens and grass, the sub-soil being of clay-slate and quartz-rock alternating. The soil is now greatly improved by the *humus* formed from the rich fall of foliage annually, but the peaty nature of the ground is still very apparent in many places. The age of the plants at time of planting is said to have been "2 years seedling, twice and thrice transplanted," and the planting-method adopted seems probably to have been a rough form of pitting, though this is not clearly stated in the interesting article on "*Plantations on the Estate of Benmore and*

Kilmun, Argyllshire," published in the "*Transactions of the Highland and Agricultural Society of Scotland*" for 1883 (Fourth Series, Vol. XV., pages 131-142). The hillside is so steep that the planters are said to have been obliged to kneel on the ground while planting, to avoid slipping down the hill. The local rainfall varies from about 90 to 120 inches a year, and is so irregular that an annual average figure might be so far from fairly constant as to be more misleading than useful.

The measurements of girth (at 5 feet up) made first on 1st May, 1911, and again on 17th February, 1912, are as shown below; but it must be remarked that the plantation was thinned *for the first time* during the winter of 1910-1911, and that a considerable number of small suppressed poles (chiefly Spruce and Larch), ought then to have been removed, in place of being numbered and measured on 1st May, 1911, and entered as "dead or suppressed," on 17th February, 1912. These dead and suppressed poles have therefore been eliminated from the list, and have not been included in estimating the girth-increment that has accrued throughout the sample-plot during the year 1911.

Serial No. of Stem.	Kind of Tree.	Girth on 1st May, 1911.		Girth on 17th February, 1912.		Girth-Increment during growing-period in 1911.	
		Inches.	Eighths.	Inches.	Eighths.	Inches.	Eighths.
1	Douglas Fir,	41	4	42	4	1	—
2	,,	30	4	31	—	—	4
3	,,	24	4	25	1	—	5
4	,,	30	—	31	1	1	1
5	,,	18	—	18	7	—	7
6	,,	39	4	41	2	1	6
7	,,	29	—	30	5	1	5
8	Larch, - -	19	—	19	6	—	6
9	Douglas Fir,	33	4	35	1	1	5
10	Larch, - -	19	4	20	4	1	—
11*	Spruce, -	(9	4	Suppressed)		—	—
12*	Douglas Fir,	(10	—	Suppressed)		—	—
13	,,	24	—	25	2	1	2
14	,,	19	—	19	6	—	6
15*	Larch, - -	(12	4	Suppressed)		—	—
16	,, - -	21	—	21	6	—	6
17	Douglas Fir,	30	—	31	3	1	3
18	,,	30	—	31	—	1	—
19	,,	19	—	19	5	—	5

Serial No. of Stem.	Kind of Tree.	Girth on 1st May, 1911.		Girth on 17th February, 1912.		Girth-Increment during growing-period in 1911.	
		Inches.	Eighths.	Inches.	Eighths.	Inches.	Eighths.
20	Spruce, -	17	—	17	5	—	5
21	Douglas Fir,	19	4	20	—	—	4
22	,,	31	—	32	1	1	1
23*	Spruce, -	(17	—	Suppressed)		—	—
24*	Douglas Fir,	(11	4	Suppressed)		—	—
25	,,	24	—	25	—	1	—
26	,,	26	—	26	6	—	6
27*	Spruce, -	(13	4	Suppressed)		—	—
28	Douglas Fir,	21	4	22	1	—	5
29	,,	25	4	26	1	—	5
30	,,	23	4	24	4	1	—
31	,,	29	—	30	4	1	4
32	,,	27	—	28	—	1	—
33	,,	25	—	25	6	—	6
34	,,	14	4	15	2	—	6
35	,,	12	4	13	2	—	6
36	,,	24	—	24	6	—	6
37	,,	28	2	29	1	—	7
38	Thuja, - -	18	4	19	2	—	6
39	Douglas Fir,	13	4	14	3	—	7
40	Larch, - -	15	2	16	4	1	2
41	Spruce, -	22	2	23	3	1	1
42	Larch, - -	15	6	16	3	—	5
43	Douglas Fir,	11	6	12	3	—	5
44	Spruce, -	15	—	15	4	—	4
45	Douglas Fir,	29	6	32	—	2	2
46	,,	24	2	25	3	1	1
47	Thuja, - -	12	—	12	2	—	2
48	Douglas Fir,	14	4	15	1	—	5
49	,,	32	4	33	4	1	—
50	,,	33	—	34	4	1	4
51	,,	31	—	32	1	1	1
52	,,	30	4	31	4	1	—
53*	,,	(11	4	Suppressed)		—	—
54	,,	29	6	31	4	1	6
55	,,	25	4	26	4	1	—
56	,,	26	4	27	—	—	4
57	,,	48	2	49	6	1	4
58	,,	25	—	25	3	—	3
59	,,	24	—	24	4	—	4
60	,,	37	4	38	6	1	2
61	,,	42	—	43	1	1	1
62	Larch, - -	16	2	16	5	—	3
63	Douglas Fir,	24	6	25	6	1	—
64	,,	14	4	15	1	—	5
65	,,	25	—	26	4	1	4
66	,,	18	2	18	7	—	5
67	,,	23	2	23	6	—	4
68	Larch, - -	22	4	23	2	—	6
69	Douglas Fir,	26	2	27	2	1	—

Serial No. of Stem.	Kind of Tree.	Girth on 1st May, 1911.		Girth on 17th February, 1912.		Girth-Increment during growing-period in 1911.	
		Inches.	Eighths.	Inches.	Eighths.	Inches.	Eighths.
70	Douglas Fir,	20	—	20	7	—	7
71	Thuja, - -	24	—	24	7	—	7
72	Larch, - -	16	2	17	1	—	7
73*	Thuja, - -	(14	—	Suppressed)		—	—
74	Douglas Fir,	26	2	26	7	—	5
75	,,	21	—	21	3	—	3
76	,,	21	2	22	—	—	6
77	,,	36	—	37	—	1	—
78	,,	19	4	19	6	—	2
79	,,	25	4	26	6	1	2
80	,,	34	4	35	6	1	2
81	Larch, - -	15	—	15	4	—	4
82	Douglas Fir,	29	6	30	7	1	1
83*	Larch, - -	(12	—	Suppressed)		—	—
84*	Thuja, - -	(12	—	Dead)	—	—	—
85	Douglas Fir,	25	4	26	5	1	1
86*	Larch, - -	(14	6	Dead)	—	—	—
87	,, - -	15	6	16	—	—	2
88	Douglas Fir,	13	4	14	—	—	4
89	,,	23	4	24	2	—	6
90	Larch, - -	16	—	16	2	—	2
91	Douglas Fir,	24	4	25	3	—	7
92	,,	33	—	33	6	—	6
93	,,	15	4	15	6	—	2
94	Thuja, - -	15	2	15	3	—	1
95	Douglas Fir,	24	4	25	4	1	—
96	,,	17	6	18	3	—	5
97	Spruce, -	24	—	25	4	1	4
98	Douglas Fir,	47	4	48	6	1	2
99*	Larch, - -	(10	2	Suppressed)		—	—
100*	,, - -	(14	—	,,	)	—	—
101	,, - -	14	2	14	6	—	4
102	Douglas Fir,	25	6	26	—	—	2
103	,,	26	4	27	—	—	4
104*	Larch, - -	(9	2	Suppressed)		—	—
105	,, - -	15	4	15	6	—	2
106	Douglas Fir,	36	—	37	—	1	—
107	,,	17	—	17	2	—	2
Total Girthage, omitting the 14 Dead and Suppressed Poles,		2,245	2	2,325	2	80	—

* The numbers of the 14 dead and suppressed trees are cancelled, and will therefore not appear in the list for 1913 and following years.

That is to say, the total girth-increment at 5 feet up, has been 80 inches during 1911 ; and the 93 individual stems have increased

on the average from 24·14 to 25·00 inches, or an average girth-increment of 0·86 inches per stem. This represents an average increment on the average basal area or stem-superficies from $\frac{(24{\cdot}14)^2}{4\pi}$ to $\frac{(25)^2}{4\pi}$, or from $582{\cdot}7396 \div 12{\cdot}56 = 46{\cdot}39$ square inches to $625 \div 12{\cdot}56 = 49{\cdot}76$ square inches, and amounting on the average to 3·37 square inches per stem; and the percentage of increment in superficies per average individual stem is therefore $7\frac{1}{4}$ per cent., as shown by the equation, $46{\cdot}39 : 3{\cdot}37 = 100 :$ **7·26 per cent.**

If one applies Pressler's formula, $\frac{D^2 - d^2}{D^2 + d^2} \times \frac{200}{n}$, then ($n$ here being 1 year), the percentage of the current annual girth-increment is found to be as follows:—Mean girth of 24·14 inches = a mean diameter of 7·68 inches, on 1st May, 1911; mean girth of 25·00 inches = a mean diameter of 7.96 inches, on 17th February, 1912.

$$\therefore \frac{D^2 - d^2}{D^2 + d^2} \times \frac{200}{n} = \frac{(63{\cdot}36 - 58{\cdot}98) \times 200}{63{\cdot}36 + 58{\cdot}98} = \frac{4{\cdot}38 \times 200}{122{\cdot}34} = \frac{876}{122{\cdot}34} =$$

$$= \mathbf{7{\cdot}16} \text{ per cent.};$$

and Schneider's formula gives a similar result—

$$\frac{D - d}{D + d} \times \frac{400}{n} = \frac{0{\cdot}28 \times 400}{15{\cdot}64} = \frac{112}{15{\cdot}64} = \mathbf{7{\cdot}16} \text{ per cent.}$$

Eliminating the 14 dead or completely suppressed poles that should have been thinned out in the winter of 1910-11, the sample-plot of one-fifth of an acre contains 107 – 14 = 93 stems, or equal to 465 per acre; and of these probably from 9 to 10 per acre and per annum will on the average become suppressed and be removed as thinnings before this crop will, 27 years hence, be 60 years of age, when it may be expected to have probably attained its financial maturity with a final crop of about 200 trees per acre. It will therefore be of great practical importance to see what girth-increment has taken place on the 40 largest stems in the sample-plot, and to obtain from them some idea of the percentage of increment which they have shown during the year 1911. These 40 dominant trees are those which girthed 25 inches or above, on 1st May, 1911; and they are enumerated in the following list, all being Douglas Fir:—

Serial No. of Tree.	Kind of Tree.	Girth on 1st May, 1911.		Girth on 17th February, 1912.		Girth-Increment during growing-period in 1911.	
		Inches.	Eighths.	Inches.	Eighths.	Inches.	Eighths.
1	Douglas Fir,	41	4	42	4	1	—
2	,,	30	4	31	—	—	4
4	,,	30	—	31	1	1	1
6	,,	39	4	41	2	1	6
7	,,	29	—	30	5	1	5
9	,,	33	4	35	1	1	5
17	,,	30	—	31	3	1	3
18	,,	30	—	31	—	1	—
22	,,	31	—	32	1	1	1
26	,,	26	—	26	6	—	6
29	,,	25	4	26	1	—	5
31	,,	29	—	30	4	1	4
32	,,	27	—	28	—	1	—
33	,,	25	—	25	6	—	6
37	,,	28	2	29	1	—	7
45	,,	29	6	32	—	2	2
49	,,	32	4	33	4	1	—
50	,,	33	—	34	4	1	4
51	,,	31	—	32	1	1	1
52	,,	30	4	31	4	1	—
54	,,	29	6	31	4	1	6
55	,,	25	4	26	4	1	—
56	,,	26	4	27	—	—	4
57	,,	48	2	49	6	1	4
58	,,	25	—	25	3	—	3
60	,,	37	4	38	6	1	2
61	,,	42	—	43	1	1	1
65	,,	25	—	26	4	1	4
69	,,	26	2	27	2	1	—
74	,,	26	2	26	7	—	5
77	,,	36	—	37	—	1	—
79	,,	25	4	26	6	1	2
80	,,	34	4	35	6	1	2
82	,,	29	6	30	7	1	1
85	,,	25	4	26	5	1	1
92	,,	33	—	33	6	—	6
98	,,	47	4	48	6	1	2
102	,,	25	6	26	—	—	2
103	,,	26	4	27	—	—	4
106	,,	36	—	37	—	1	—
—	—	1,244	4	1,288	1	43	5

Thus the average girth-increment on each of these 40 dominant stems has been 1·09 inches, the individual stems having increased from an average of 31·11 up to an average of 32·20 inches, at 5 feet up; and this represents an average increment on the

basal area or stem-superficies from $\frac{(31{\cdot}11)^2}{4\pi}$ to $\frac{(32{\cdot}2)^2}{4\pi}$, or from $967{\cdot}8321 \div 12{\cdot}56 = 77{\cdot}05$ square inches to $1036{\cdot}84 \div 12{\cdot}56 = 82{\cdot}55$ square inches; and the percentage of increment in superficies, per average stem, is therefore **7·13 per cent.**, as shown by the equation, $77{\cdot}05 : 5{\cdot}50 = 100 : 7{\cdot}13$.

The apparent discrepancy that the 40 dominant and quickest-growing trees (which have undoubtedly made the largest actual growth in volume during the year), show a smaller percentage of girth-increment than the average for the whole crop, is of course due to the calculation of the percentage being based on a considerably larger average superficies per stem (77·05 square inches) than is the case when the calculation is based upon the average superficies (46·39 square inches) for all the 93 stems growing on the sample plot.

As the mean girth of 31·11 inches (divided by $\pi = 3{\cdot}14$), gives a diameter of 9·90 inches, and that of 32·20 inches gives a diameter of 10·25 inches, Pressler's formula shows a current annual increment of **6·94** per cent. on the girth-superficies, while Schneider's formula also shows **6·94** per cent. for these 40 trees.*

Owing to the very close canopy formed by the tree-crowns, it was found impossible to obtain exact data as to the average current rate of growth in height; but, as regards two trees whose crowns happened to be visible with less than the average difficulty and indistinctness, tree No. 61 was found by measurement with the telescope-hypsometer to be 70 feet in height, and to be in vigorous height-growth; while tree No. 70 had grown fully 10 feet during the last 3 years, or at an average rate of over 3 feet a year; and in another part of this same plantation, close below the sample-plot, the average rate of height-growth during each of the last 5 years was fully $2\frac{1}{2}$ feet, and was being well maintained. The percentage of growth in height therefore appears to be about $3\frac{1}{3}$ to $3\frac{1}{2}$ per cent., and may be estimated as

---

* Pressler's formula—

$$\frac{D^2 - d^2}{D^2 + d^2} \times \frac{200}{n} = \frac{(105{\cdot}06 - 98{\cdot}01)200}{105{\cdot}06 + 98{\cdot}01} = \frac{7{\cdot}05 \times 200}{203{\cdot}07} = \frac{1410}{203{\cdot}07} = 6{\cdot}94 \text{ per cent.}$$

Schneider's formula—

$$\frac{D - d}{D + d} \times \frac{400}{n} = \frac{(10{\cdot}25 - 9{\cdot}90)400}{10{\cdot}25 + 9{\cdot}90} = \frac{0{\cdot}35 \times 400}{20{\cdot}15} = \frac{140}{20{\cdot}15} = 6{\cdot}94 \text{ per cent.}$$

being **at least 3 per cent. on the average.** Permission was unfortunately not obtainable for felling an average stem of 25·00 inches in girth, to ascertain exactly the cubic contents of the same, and through that (by multiplication), of the total cubic contents on the sample-plot, and per acre. In default of this, the best that could be done was to measure a windfall tree which was lying near by, at the upper edge of a shooting-ride, and which was still partially green, though it had made practically no growth in height during the 2 years it has now been lying flat on the ground. As might be expected from such a tree on an exposed windward edge, the stem is relatively large in girth at the base, poor in height growth, and conical and very tapering—far less full-wooded in the bole, and with a much lower form-factor, than the trees growing in the sample-plot and the adjoining parts of the wood. It was, however, the only stem on which accurate measurements could be made, and these were as follows:—total length, $58\frac{1}{4}$ feet; girth at 5 feet up, $26\frac{3}{4}$ inches; girth of 10 inches, at 44 feet up; while the girth at $44 \div 2 = 22$ feet up, was $21\frac{3}{4}$ inches. Deducting the $1\frac{3}{4}$ inches as bark-allowance (which is excessive for a smooth-barked young tree of this description), the square of quarter-girth cubic contents are therefore = 25 square inches × 44 feet ÷ 144 = 1,100 ÷ 144 = 7·63 cubic feet. But even taking only 7 cubic feet per stem as the average for the sample plot, notwithstanding the better growth in height and the more full-wooded form of the stems there, this would give $93 \times 7 = 651$ cubic feet for the sample-plot, and $651 \times 5 = 3{,}255$ cubic feet per acre as the young crop now on the ground; and this is equal to an average growth in volume of $98\frac{2}{5}$ cubic feet (square of quarter girth-measurement, and with full bark-allowance deducted) per acre and per annum during the whole of the 33 years since the formation of the plantation in the spring of 1879. And as the plantation is just entering into its most vigorous period of growth in volume (and immediately after being thinned for the first time), it may safely be estimated that the current increment on the 93 trees in the sample-plot is at present not less than 150 cubic feet per acre and per annum, and may probably exceed that. Indeed, as the total increment in cubic contents consists in each year of the additional growth in girth, plus the growth in height, it may fairly be assumed (in default of exact measurements and stem-analysis, not

in this case obtainable) that the mean of the percentages of the current annual growth in girth and growth in height will give a fairly correct estimate of the percentage of current annual growth in cubic contents. In such case it would be $\frac{1}{2}(7+3) = 5$ **per cent.**; and with a present volume of 3,255 cubic feet per acre, the increment for the year 1912 may be estimated at 5 per cent. of this, or $162\frac{3}{4}$ cubic feet, making a total of 3,417 cubic feet when the plantation will have completed its 34th year of growth, and then showing an average annual increment of $100\frac{1}{2}$ cubic feet (square of quarter girth measurement, and with full bark-allowance deducted).

Immediately to the north of the sample-plot, the young wood remains as yet unthinned; and from the over-crowded appearance it represents, the deduction may safely be drawn that 4×4 feet is unnecessarily close planting for Douglas Fir, and that from 5×5 feet up to even 6×6 feet is quite close enough, unless an exceptionally good market for small poles be likely to make early thinnings profitable.

In conclusion, I take this opportunity of thanking Mr. Angus Cameron, the factor on the Benmore Estate, and Mr. Feaks, the forester, for their very kind assistance in making this experimental investigation.

Bulletin No. 60.

The West of Scotland Agricultural College.

REPORT

ON

EXPERIMENTS

ON THE

MANURING OF TURNIPS

In 1909, 1910, and 1911.

BY

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GLASGOW, 1912.

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Report on Experiments on the Manuring of Turnips in 1909, 1910, and 1911.

By JAMES WYLLIE, B.Sc., N.D.A.(Hons.).

The experiments which form the subject of the following report were carried out in the years 1909, 1910, and 1911, on 45 farms distributed throughout the central and south-western counties of Scotland. Full details of the experiments, with the names of the farms, the manures applied, and the returns obtained, are contained in Tables I.-VI. on pp. 34-39 of this report. The experiments were designed by Sir Robert P. Wright, formerly Principal of this College, and now Chairman of the Board of Agriculture for Scotland.

Objects of the Experiments.

In drawing up the plan of these experiments, consideration was given to the results which had been obtained from previous experiments carried out by the College on the manuring of this crop, and in order that the plan may be more fully understood, the conclusions which were drawn from certain of the previous experiments—as contained in Bulletins 37 and 52—are here recapitulated.

Conclusions from Experiments of 1904 and 1905 (Bulletin No. 37).

" 1. That superphosphate forms a more effective manure for the turnip crop when applied in the drills in spring than when broadcast on the land in winter.
2. That basic slag also generally produces larger crops when applied in the drills in spring than when broadcast in winter.
3. That kainit and the other potash manures also generally, though not invariably, give the best results on the turnip crop when applied in the drills in spring.
4. That the relative efficacy of the winter and the spring applications varies with the season, and that in some years the spring application may be only moderately, if at all, superior.
5. That potash appears to be of nearly equal efficacy for the turnip crop in the three forms of kainit, muriate of potash, and potash manure salt, but that kainit is somewhat the more effective form of the three.
6. That lime nitrogen appears likely to prove a valuable nitrogenous manure for the turnip crop."

Conclusions from Experiments of 1906 and 1907 (Bulletin No. 52).

" 1. That phosphoric acid applied to the turnip crop, half in the form of superphosphates and half in the form of basic slag, will produce a crop as large as if the phosphoric acid were applied wholly in the form of superphosphate.
2. That the presence of a sufficient quantity of potash in a turnip manure is essential to the production of large crops, and that the omission to supply potash causes a large reduction both in yield and in profits.
3. That the 30 per cent. potash manure salt is as effective a manure as kainit for the supply of potash to the turnip crop.
4. That, on the average of the farms, nitrogen in the turnip manure also produced an increase of crop. The effects of the nitrogenous manures varied, however, with the season, and according to the condition of the soil and the manner of application; and skill and judgment require to be exercised in their employment.
5. That, in these experiments, nitrogen proved to be a less important and less effective ingredient in a turnip manure than potash.

6. That the common practice of applying nitrate of soda to the turnip crop in the form of a top dressing is not wholly supported by the results of these experiments. The effects seem to vary with the season, but on the whole the best results have been obtained in the experiments by the application of nitrate of soda in the drills.
7. That the new manure, nitrogen lime or lime nitrogen, proved itself to be a thoroughly effective turnip manure, and in 1907 showed itself on the average results to be quite as valuable a source of nitrogen for the turnip crop as either nitrate of soda or sulphate of ammonia. Applied to soils for which it is adapted, it appears to be capable of giving results on the turnip crop superior to either of these manures."

Keeping these conclusions in mind, the experiments in question were planned with the following objects:—

(1) To compare the efficacy of potash and nitrogen in a turnip manure.
(2) To compare the efficacy of kainit and potash manure salts as a source of potash for turnips.
(3) To compare the efficacy of a small and a large top-dressing of nitrate of soda.
(4) To compare the efficacy of nitrate of soda in the drills and nitrate of soda applied as a top-dressing.
(5) To compare the efficacy of nitrate of soda and nitrate of lime as a top-dressing.
(6) To compare the efficacy of sulphate of ammonia and lime nitrogen (calcium cyanamide) both applied in the drills.
(7) To compare the efficacy of sulphate of ammonia and nitrate of lime, both applied in the drills.
(8) To compare the efficacy of nitrate of lime in the drills and nitrate of lime top-dressed.
(9) To compare the efficacy of nitrate of lime and lime-nitrogen both applied in the drills.
(10) To determine the best nitrogenous manurial dressing for turnips.

Plan of the Experiment.

The plan of the experiment, which was the same in the three seasons, was as follows:—

PLAN OF TURNIP EXPERIMENT IN 1909, 1910, AND 1911.

No. of Plot.	Kind of Manure.	Quantities per Acre.
1	Unmanured.	
2	Superphosphate, in the drills,	3 cwts.
	(*a*) Basic Slag, in the drills,	
	Kainit. in the drills,	3 cwts.
3	Superphosphate, in the drills,	3 cwts.
	(*a*) Basic Slag, in the drills,	
	Sulphate of Ammonia, in the drills,	½ cwt.
	Nitrate of Soda, top dressed,	½ cwt.
4	Superphosphate, in the drills	3 cwts.
	(*a*) Basic Slag, in the drills,	
	(*b*) Potash Manure Salt, in the drills.	
	Sulphate of Ammonia, in the drills,	½ cwt.
	Nitrate of Soda, top dressed,	½ cwt.
5	Superphosphate, in the drills,	3 cwts.
	(*a*) Basic Slag, in the drills,	
	Kainit, in the drills,	3 cwts.
	Sulphate of Ammonia, in the drills,	½ cwt.
	Nitrate of Soda, top dressed,	½ cwt.
6	Superphosphate, in the drills,	3 cwts.
	(*a*) Basic Slag, in the drills,	
	Kainit, in the drills,	3 cwts.
	Sulphate of Ammonia, in the drills,	½ cwt.
	Nitrate of Soda, in the drills,	½ cwt.
7	Superphosphate, in the drills,	3 cwts.
	(*a*) Basic Slag, in the drills,	
	Kainit, in the drills,	3 cwts.
	Sulphate of Ammonia, in the drills,	½ cwt.
	Nitrate of Soda, top dressed,	1 cwt.
8	Superphosphate, in the drills,	3 cwts.
	(*a*) Basic Slag, in the drills,	
	Kainit, in the drills.	3 cwts.
	Sulphate of Ammonia, in the drills,	½ cwt.
	(*d*) Nitrate of Lime, top dressed,	
9	Superphosphate, in the drills,	3 cwts.
	(*a*) Basic Slag, in the drills,	
	Kainit, in the drills,	3 cwts.
	(*c*) Nitrate of Lime, in the drills,	
	(*d*) Nitrate of Lime, top dressed,	
10	Superphosphate, in the drills,	3 cwts.
	(*a*) Basic Slag, in the drills,	
	Kainit, in the drills,	3 cwts.
	(*e*) Nitrate of Lime, in the drills,	
11	Superphosphate, in the drills,	3 cwts.
	(*a*) Basic Slag, in the drills,	
	Kainit, in the drills,	3 cwts.
	(*e*) Lime Nitrogen, in the drills,	
12	Superphosphate, in the drills,	3 cwts.
	(*a*) Basic Slag, in the drills,	
	Kainit, in the drills,	3 cwts.
	(*c*) Lime Nitrogen, in the drills,	
	Nitrate of Soda, top dressed,	½ cwt.
13	Unmanured.	

(*a*) Containing Citric Acid soluble Phosphoric Acid equal to that contained in 3 cwts. Superphosphate.
(*b*) Containing Potash equal to that contained in 3 cwts. of Kainit.
(*c*) ,, Nitrogen ,, ,, ½ cwt. Sulphate of Ammonia.
(*d*) ,, Nitrogen ,, ,, ½ cwt. of Nitrate of Soda.
(*e*) ,, Nitrogen ,, applied to Plot 6.

It may be advisable at this point to offer some explanation why artificial manures only have been used in these experiments. It must be distinctly understood that it is *not* because farmyard manure is considered an unsuitable manure for turnips: every turnip-grower well knows how erroneous that view would be. The explanation lies in the purposes for which the experiments were designed. It is widely recognised that farmyard manure varies greatly in composition, and where it is used the experimental error is apt to be very great, unless careful precautions are taken. The object of these experiments was to compare the efficacy of various artificial manures, and it is obvious that this could most accurately be done by using artificial manures only. Incidentally, of course, the experiments show that good crops of turnips can be grown, and grown economically, with artificial manures alone, but it was not the intention to try to induce farmers to forsake the commendable practice of using a certain dressing of farmyard manure for this crop. We mention this merely to meet, in advance, a criticism which might be made by a certain class of agricultural critics.

The Weather and Average Yields of 1909, 1910, and 1911.

In no case was the weather of the three seasons under consideration specially favourable to the production of large turnip crops. The year 1909 was characterised by its cold and sunless summer and autumn, by an exceptionally wet October, which played great havoc with the corn harvest, and by extremely severe frosts in November, which caused great damage amongst turnip crops not then lifted. Turnips brairded fairly well, but thereafter growth was slow until the autumn. In 1910, both April and the first half of May were cold and wet, but the second half of May and a great part of June were dry and sunny. In many cases turnips had to be re-sown. August was extremely wet, while September and October were abnormally dry and summery. November was characterised by a large number of frosts, the mean temperature being the lowest on record. The summer and

autumn of 1911 are still fresh in everyone's mind, as being the sunniest, driest, and warmest for many years. Consequently it was in many districts a disastrous season for the turnip crop. Re-sowing was very common, and the plants were very slow in coming to the hoe. Mildew was very prevalent in the autumn, and altogether there was a decided shortage in this crop.

The suitability of the weather of each year for the turnip crop can approximately be gauged by the number of experiments which had to be abandoned on account of irregular brairding, or for some other reason closely connected with the weather. The following shows the number of experiments actually put down, and the number successfully completed :—

	1909.	1910.	1911.
Number put down, -	19	28	20
Number completed, -	16	20	9

The official returns of the average yields per acre of turnips and swedes in Scotland for 1909-1911 are also suggestive, They are as follows :—17·3 tons in 1909, 18·45 tons in 1910, and 14·25 tons in 1911—the average for the ten years 1901-1910 being 16·37 tons.

Nature of Soils and Varieties Grown.

It will be seen from Tables II., IV., and VI. that a great variety of soils are involved in the experiments. Owing, however, to the vagueness of meaning which attaches to the terms used in describing soils, it was not found possible to classify the results according to a few more or less clearly defined soil types—as would seem desirable. In this report, the term " turnips " includes both " swedes " and " yellow turnips " as it commonly does throughout Scotland.

Analysis of Results.

(1) Relative Efficacy of Potash and Nitrogen (Plots 2, 3, and 5).

No. of Plot.	Differential Treatment.	Average Yield per Acre.								
		1909.			1910.			1911.		
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.
3	Phosphates and Nitrogen, - -	19	8	2	20	16	3	22	0	3
5	Phosphates, Nitrogen, *and Potash*,	23	1	1	24	14	3	24	0	1
	Increase due to Potash, - -	3	12	3	3	18	0	1	19	2
	Cost of increase per ton, - -	2/0			1/10			3/6		
2	Phosphates and Potash, - -	19	11	0	22	13	2	21	13	3
5	Phosphates, Potash, *and Nitrogen*,	23	1	1	24	14	3	24	0	1
	Increase due to Nitrogen, - -	3	10	1	2	1	1	2	6	2
	Cost of increase per ton, - -	3/9			6/4			5/8		

It appears from these figures that the relative efficacy of potash and nitrogen in a turnip manure varies from season to season, but even in 1911, when the average increase in crop was greater from the nitrogen than from the potash, the increase from the potash manure was secured at less cost per ton of turnips. If we take the feeding value of the turnips at 8s. per ton, then it is clear that the complete dressing of phosphates, potash, and nitrogen is the most economical one. A consideration of the average results alone, however, does not emphasise sufficiently the great necessity there is for potash on light, sandy, and peaty soils; for, on 11 farms on which the soil was light or peaty the average increase from 3 cwts. kainit was no less than fully 6 tons per acre, costing about 1s. per ton. As regards nitrogen, there does not seem to be any very definite relation between the kind of soil and the efficacy of nitrogenous manures. It may be noticed that Plot 5 has been selected for making the above comparisons, because the manurial dressing applied

to it is generally looked upon as a "standard" one for average purposes. Had Plot 6 been taken, the increases from both potash and nitrogen would have been slightly greater.

(2) KAINIT *v.* POTASH MANURE SALTS (Plots 4 and 5).

No. of Plot.	Differential Treatment.	Average Yield per Acre.								
		1909.			1910.			1911.		
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.
4	Phosphates, Nitrogen, and Potash Salts, - - - - - -	23	1	3	23	12	1	23	5	2
5	Phosphates, Nitrogen, and Kainit,	23	1	1	24	14	3	24	0	1
	Difference in favour of Kainit, -	−0	0	2	1	2	2	0	14	3

These results confirm those of previous experiments (see page 18), viz., that, on the average, kainit and potash salts are about equally efficacious as a source of potash for turnips, with the balance swaying slightly in favour of kainit. An inspection of the individual results, however, brings out the noteworthy fact that the kainit was superior to the potash salts on 24 farms out of 44, that is, according to these experiments the chances of kainit giving better results than potash salts are as 5 to 4.

(3) ½ CWT. *v.* 1 CWT. NITRATE OF SODA, TOP DRESSED (Plots 5 and 7).

No. of Plot.	Differential Treatment.	Average Yield per Acre.								
		1909.			1910.			1911.		
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.
5	½ cwt. Nitrate of Soda, top dressed,	23	1	1	24	14	3	24	0	1
7	1 Do. do. do.,	23	14	0	25	12	2	23	2	1
	Increase from larger dressing, -	0	12	3	0	17	3	0 (decrease).	18	0

Taking these results as a whole, it cannot be said that the extra ½ cwt. nitrate of soda has given a profitable increase.

Even in 1910, when the increase is greatest, it is obtained at a cost of about 6s. 3d. per ton of turnips, while in 1911 a decrease in crop has actually resulted—due, no doubt, to the forcing up of a large growth of shaws without a corresponding increase in the bulbs. In no fewer than 14 cases out of 43 did the extra nitrate of soda cause a decrease in crop, in 4 cases with yellow turnips and in 10 cases with swedes. If we take 6s. per ton as being the minimum feeding value of a ton of turnips, and 6s. also as being about the average cost of a dressing of ½ cwt. nitrate of soda, then it appears that the extra ½ cwt. nitrate of soda *was* profitable on 19 farms out of 43, as in all these cases the increase produced was at least one ton per acre, and in 5 cases ranged up to as high as 3 to 7 tons per acre. To sum up, although on the average the increased nitrate of soda did not prove profitable, in a large number of cases it was profitable.

(4) Nitrate of Soda top dressed *v.* Nitrate of Soda in the drills (Plots 5 and 6).

No. of Plot.	Differential Treatment.	Average Yield per Acre.								
		1909.			1910.			1911.		
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.
5	Nitrate of Soda, top dressed, -	23	1	1	24	14	3	24	0	1
6	Do. in drills, - -	23	8	2	25	6	2	24	16	3
	Difference, in favour of drill application, - - - -	0	7	1	0	11	3	0	16	2

The results from these two plots are of more than usual interest. It is generally recommended that nitrate of soda should always be used as a top-dressing after growth has commenced in order to prevent danger of washing out by rain. The experiments of 1906 and 1907 indicated (see page 19) that this rule does not hold true for turnips, and this conclusion has received confirmation from the results of the experiments at present under review. In each year the difference was, on the average, slightly in favour of the appli-

cation in the drills, and this held good in 24 farms out of 43, while the top-dressing was superior on 16 farms. In 3 cases the yields were the same. It would appear that the method of top-dressing is only likely to be superior under abnormal conditions, for example, where the turnips have received a check after hoeing, either through very dry or very wet, cold weather. Under normal conditions, the method of applying in the drills is to be preferred. It is obvious, of course, that at sowing time, when the drill applications are made, one will have to decide whether or not to risk the after-conditions being normal.

This is a result of some importance to turnip growers, and especially in seasons when nitrate of soda can be bought at a lower rate than sulphate of ammonia, and also where basic slag is being used in the drills. Nitrate of soda could be used instead of sulphate of ammonia in the drills, and thus avoid not only having to apply the drill manures in two dressings (since slag cannot safely be mixed with sulphate of ammonia), but also the labour of top-dressing the nitrate of soda.

(5) Nitrate of Soda *v.* Nitrate of Lime, as a top dressing (Plots 5 and 8).

No. of Plot.	Differential Treatment.	Average Yield per Acre.								
		1909.			1910.			1911.		
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.
5	Nitrate of Soda, top dressed, -	23	1	1	24	14	3	24	0	1
8	Nitrate of Lime, Do.,	23	6	0	24	19	2	22	16	2
	Difference, - - - - -	0	4	3	0	4	3	1	3	3

In 1909 and 1910 the average returns from these two manures applied as top-dressings are practically the same, while in 1911 there is a slight difference in favour of nitrate of soda. But, on the other hand, the nitrate of lime was superior on 24 farms out of 43, as against 17 farms on which the nitrate of soda was the better top-dressing. On 2 farms

the returns were the same. So that, on the average, the chances would seem to be about 3 to 2 in favour of nitrate of lime, and not in favour of nitrate of soda. It should here be remarked that in a number of cases the nitrate of lime was not in very favourable mechanical condition when sown, having been stored for some time in non-air-tight bags, and thus absorbed sufficient moisture from the air to render it somewhat soft and sticky; and had this not been so, the results from this manure would very probably have been still more satisfactory. At any rate, it is clearly proved that as a top-dressing for turnips nitrate of lime is at least the equal, if not the superior, of nitrate of soda.

(6) Sulphate of Ammonia *v.* Lime-Nitrogen, in the drills (Plots 5 and 12).

No. of Plot.	Differential Treatment.	Average Yield per Acre.								
		1909.			1910.			1911.		
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.
5	Sulphate of Ammonia, in drills, -	23	1	1	24	14	3	24	0	1
12	Lime Nitrogen, Do.,	22	11	0	24	10	3	22	4	3
	Difference, in favour of Sulphate of Ammonia, - - - -	0	10	1	0	4	0	1	15	2

In each year there is, on the average, a slight difference in favour of sulphate of ammonia, and this holds good on 22 farms out of 42, as against 19 on which the lime-nitrogen proved superior. On one farm the returns were the same. These results fully confirm the conclusion already formed (see pp. 18, 19), viz., that as a source of drill nitrogen for turnips lime-nitrogen is of about equal value to sulphate of ammonia. An inspection of the individual results does not, unfortunately, show any well-marked relation between the kind of soil and the superiority of either of the manures. Lime-nitrogen has often done well on light soils, clays, and peats, which are presumably deficient in lime, but it did not always prove superior to sulphate of

ammonia on such soils. In fact, nothing short of a full knowledge of all the local conditions would enable one to say, with any degree of assurance, whether sulphate of ammonia or lime nitrogen would be likely to prove the more profitable.

(7) Sulphate of Ammonia *v.* Nitrate of Lime, in the drills (Plots 8 and 9).

No. of Plot.	Differential Treatment.	Average Yield per Acre.								
		1909.			1910.			1911.		
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.
8	Sulphate of Ammonia, in drills, -	23	6	0	24	19	2	22	16	2
9	Nitrate of Lime, Do.,	22	8	2	23	15	2	23	17	1
	Difference, - - - - - -	0	17	2	1	4	0	1	0	3

In both 1909 and 1910 there is an average difference of about 1 ton per acre in favour of sulphate of ammonia, while in 1911 there is a similar difference in favour of nitrate of lime. Taking the three years together, sulphate of ammonia was superior on 24 farms out of 44, as against 18 farms on which the nitrate of lime was the better. It does not seem, therefore, that, under normal conditions, it will be advisable to substitute nitrate of lime for sulphate of ammonia, the chances being about 3 to 2 against it being profitable.

(8) Nitrate of Lime, top dressed *v.* Nitrate of Lime, in the drills (Plots 9 and 10).

No. of Plot.	Differential Treatment.	Average Yield per Acre.								
		1909.			1910.			1911.		
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.
9	Nitrate of Lime, top dressed, -	22	8	2	23	15	2	23	17	1
10	Do., in the drills, -	22	9	3	24	14	0	24	3	0
	Difference, in favour of drill application, - - - -	0	1	1	0	18	2	0	5	3

In each year the difference is slightly in favour of the drill application, and this result is specially noteworthy when taken in conjunction with that from Plots 5 and 6, on which nitrate of soda in the drills proved, in the majority of cases, superior to nitrate of soda top-dressed. The drill application of nitrate of lime was better than the top-dressing on 25 farms out of 44, while the top-dressing was the better on only 18 farms. In one case, the returns were the same. The same remarks as were made in discussing the drill application and top-dressing of nitrate of soda would equally apply here (see page 26).

(9) NITRATE OF LIME *v.* LIME-NITROGEN, IN THE DRILLS (Plots 10 and 11).

No. of Plot.	Differential Treatment.	Average Yield per Acre.								
		1909.			1910.			1911.		
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.
10	Nitrate of Lime, in drills, - -	22	9	3	24	14	0	24	3	0
11	Lime-Nitrogen, Do.,	22	13	1	24	0	3	23	16	1
	Difference. - - - - -	0	3	2	0	13	1	0	6	3

In 1910 and 1911 the average is slightly in favour of nitrate of lime, in 1911 of lime nitrogen, but in neither case is the difference greater than what the experimental error very probably amounts to in such experiments. The nitrate of lime is superior on 22 farms out of 44, the lime nitrogen on 20 farms, while on 2 farms the returns are the same. The relative efficacy of these two manures is apparently very largely influenced by local conditions, and without a knowledge of these it is impossible to predict with any degree of safety which will prove the more economical.

(10) The Best Nitrogenous Dressing (Plots 5 to 12).

No. of Plot.	Differential Treatment.	Average Yield per Acre.									No. of Farms on which gives best return.			
		1909.			1910.			1911.			1909.	1910.	1911.	Total
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.				
5	½ cwt. Sulphate of Ammonia, in drills, ½ cwt. Nitrate of Soda, top dressed,	23	1	1	24	14	3	24	0	1	3	2	1	6
6	½ cwt. Sulphate of Ammonia, in drills, ½ cwt. Nitrate of Soda, in drills,	23	8	2	25	6	2	24	16	3	2	6	3	11
[7	½ cwt. Sulphate of Ammonia, in drills, 1 cwt. Nitrate of Soda, top dressed,	23	14	0	25	12	2	23	2	1]	...	...	...	...
8	½ cwt. Sulphate of Ammonia, in drills, Nitrate of Lime, top dressed,	23	6	0	24	19	2	22	16	2	3	3	...	6
9	Nitrate of Lime, top dressed, Nitrate of Lime in drills,	22	8	2	23	15	2	23	17	1	1	2	2	5
10	Nitrate of Lime, in drills,	22	9	3	24	14	0	24	3	0	1	3	...	4
11	Lime-Nitrogen in drills,	22	13	1	24	0	3	23	16	1	3	...	2	5
12	Lime-Nitrogen in drills, Nitrate of Soda, top dressed,	22	11	0	24	10	3	22	4	3	3	4	1	8

It will now have become apparent that one of the main objects of these experiments is to determine the most economical nitrogenous dressing for turnips. Plots 5 to 12 all received the same basal dressing of phosphates and potash, but each got a different nitrogenous manuring.

For purposes of comparison, and in view of what has already been written (see pp. 24. 25), we shall in this place omit Plot 7 from the discussion. The cost of the nitrogenous dressing on each of the other seven plots was approximately the same, so that the dressing which gave the highest yield may

be looked upon as being, under normal circumstances, the most profitable. A glance at the above table of average yields for the three years would give one the impression that the dressing used on Plot 6, viz., ½ cwt. sulphate of ammonia and ½ cwt. nitrate of soda in the drills, was the best of all, but a critical analysis of the individual results shows that this would not be altogether correct. In fact, Plot 6 was best on only 11 farms out of 45, whereas Plot 12 was best on 8 farms, Plots 5 and 8 each best on 6 farms, Plots 9 and 11 on 5 farms each, and Plot 10 on 4 farms. These figures clearly prove how futile it would be to attempt to lay down a certain dressing as being the most economical without having regard to local conditions of soil, climate, &c., and they further show how misleading in character average results may be if considered without a careful inspection of the individual results. In fact, after making the usual and necessary allowance for the unavoidable experimental error, one would be almost justified in saying that, as far as the average results are concerned, one dressing is just as profitable as another. That this is not so, however—having regard to any single farm—is very clearly shown in the individual results.

General Observations.

On a careful inspection of the individual results contained in Tables I., III., and V. (pp. 34-38), perhaps the most striking feature is the great want of uniformity in the efficacy of any certain dressing. This has already been pointed out in considering the various nitrogenous dressings. Two conclusions may be drawn from this state of affairs. First, the experimental error in such experiments appears to be fairly high, although it is impossible to put a definite figure on it. On Farm No. 15 (Table I.), for example, 3 cwts. kainit gives an increase of about 11½ tons per acre (Plots 3 and 5), on Farm No. 7 the increase is less than a ton, while of Farm No. 1 there is actually a decrease of about 2 tons. The result on Farm No. 1 is almost certainly unreliable, due very possibly to poorer soil on the plot receiving kainit, but it is clear that part of the large increase on Farm No. 15 *may*

be due to poorer soil on the plot not receiving kainit. Other examples could be given, but this one will serve to illustrate the point we wish here to make, namely, that unless the difference between two certain dressings is very marked, or continues consistently throughout a large number of trials it is not possible to say which of the two is superior.

And in the second place, it is clear that, whatever information may be gained from a consideration of the average results of such experiments, as far as the individual farmer is concerned he will be well advised to fix his scheme of manuring according to the results of experiments on his own farm. The results of an experiment on a cold, clay soil in Lanarkshire are worthless, and may be very misleading to a farmer on light, sandy soil in Wigtownshire. For a farmer who does not himself experiment, average results may be a moderately safe guide, but for a farmer who is prepared to conduct experiments for himself, he had best leave out of account the results of other experiments, *unless he is assured that they are carried out under similar conditions of soil, climate, system of farming, &c., to his own.* Much more could be written upon this aspect of manurial experiments, but the time and the place are not opportune.

Conclusions.

Subject always to what has been said above, the following general conclusions can be drawn from the experiments under review :—

(1) Where farmyard manure is not applied, the use of both potassic and nitrogenous manures for turnips is to be recommended, but of the two the former are more essential and more likely to yield high money returns.

(2) Kainit and potash manure salts are about equally efficacious for the turnip crop.

(3) The relative efficacy of ½ and 1 cwt. nitrate of soda as a top-dressing, along with ½ cwt. sulphate of ammonia in the drills, varies very much, and the chances are slightly in favour of the ½ cwt. dressing proving the more economical.

(4) Contrary to popular opinion, ½ cwt. nitrate of soda in the drills gives, in the majority of cases, a better result than ½ cwt. top-dressed, the chances being about 3 to 2 in favour of the drill application.

(5) Also, ½ cwt. nitrate of lime in the drills gives, in the majority of cases, a better result than a similar amount top-dressed.

(6) As a top-dressing for turnips, nitrate of lime is at least the equal, and in many cases the superior, of nitrate of soda.

(7) For drill application, nitrolim is, on the average, about equally efficacious to sulphate of ammonia.

(8) For drill application, nitrolim and nitrate of lime are, on the average, about equally reliable.

(9) The best nitrogenous dressing for turnips varies very much according to local conditions, and without a knowledge of these it is impossible to give any useful opinion on the subject.

(10) The most useful results are those which the farmer obtains on his own land, and under his own special set of circumstances as regards soil, climate, system of farming, &c.

EACH PLOT,

Plot 11.	Plot 12.	Plot 13.
phate, in the drills,	Superphosphate, in the drills, 3 cwts. (*a*) Basic Slag, in the drills. Kainit, in the drills, 3 cwts. (*c*) Lime Nitrogen, in the drills. Nitrate of Soda, top dressed, ½ cwt.	No Manure.
f Roots per Acre.	Yield of Roots per Acre.	Yield of Roots per Acre.

No.	cwts.	qrs.	tons.	cwts.	qrs.	tons.	cwts.	qrs.
	0	0	11	0	0	0	0	0
1	17	0	35	17	0	14	8	2
2	13	3	20	8	2	17	5	2
3	12	0	23	5	1	10	16	0
4	17	2	21	12	3	0	0	0
5	13	2	22	13	2	0	0	0
6	0	1	38	0	0	20	0	0
7	18	2	28	13	1	11	4	2
8	12	1	24	5	3	9	15	0*
9	19	0	33	14	0	17	5	2*
10	2	2	18	14	2	12	19	1
11	2	2	23	16	3	3	11	2
12	12	0	37	3	0	25	4	0*
13	5	2	15	3	2	1	5	0
14	10	0	28	5	0	17	0	0
15	4	0	28	6	3	12	17	0
16	15	0	21	13	0	12	17	0
17	11	3	17	11	1	14	5	1
18	12	1	11	0	0*	4	12	3
19	15	0	29	10	0	26	15	0
20	14	1	490	13	3	232	1	3
	0	3	24	10	3	11	12	1
	17	0	13	7	0		...	
	14	0	£1	12	0		...	

* Estimated.

TABLE I. SHOWING THE AVERAGE RESULTS OF EXPERIMENTS ON THE MANURING OF TURNIPS IN 1909. THE LINES AND QUANTITIES OF MANURES APPLIED PER ACRE, AND THE INCREASE RESULTING IN THEIR APPLICATION.
THE COST OF THE MANURES AND THE INCREASES RESULTING IN THEIR APPLICATION.

No.	Name of Farm	County	Plot 1. Nil Manure. Yield of Roots per Acre	Plot 2. Superphosphate in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Yield of Roots per Acre	Plot 3. Superphosphate in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Nitrate of Soda, top dressed ½ cwt. Yield of Roots per Acre	Plot 4. Superphosphate in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Nitrate of Soda, top dressed ½ cwt. Yield of Roots per Acre	Plot 5. Superphosphate in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Nitrate of Soda, top dressed ½ cwt. Yield of Roots per Acre	Plot 6. Superphosphate in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Nitrate of Soda, top dressed ½ cwt. Yield of Roots per Acre	Plot 7. Superphosphate in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Sulphate of Ammonia top dressed ½ cwt. Yield of Roots per Acre	Plot 8. Superphosphate in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Sulphate of Ammonia ½ cwt. Nitrate of Soda ½ cwt. Yield of Roots per Acre	Plot 9. Superphosphate in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Nitrate of Soda 1 cwt. Yield of Roots per Acre	Plot 10. Superphosphate in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Yield of Roots per Acre	Plot 11. Superphosphate in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Nitrate of Soda in the drills ½ cwt. Yield of Roots per Acre	Plot 12. Superphosphate, in the drills at Rate of 3 cwt. per Acre, Kainit in the drills 2 cwts. Nitrate of Soda in the drills ½ cwt. Nitrate of Soda top dressed ½ cwt. Yield of Roots per Acre	Plot 13. No Manure. Yield of Roots per Acre
1	[illegible]	Angus	0 0 0	8 [illegible]	12 2 0	3 [illegible]	13 2 [illegible]	13 2 [illegible]	13 [illegible] 0	10 0 0	9 2 0	8 [illegible] 0	14 0 0	0 0 0
2	[illegible]	..	5 14 1	23 8 3	22 5 [illegible]	25 5 3	24 [illegible] 0	27 17 [illegible]	26 10 1	27 8 1	28 5 1	31 0 0	30 17 0	14 8 2
3	[illegible]	[illegible]	8 0 1	20 16 0	18 17 [illegible]	25 17 3	21 0 1	22 0 0	23 2 3	21 14 1	21 17 3	20 12 3	20 13 3	17 5 2
4	[illegible]	[illegible]	1 16 [illegible]*	22 0 3	14 3 3	26 8 2	26 10 [illegible]	24 0 2	24 16 2	25 7 3	18 5 2	26 11 0	24 12 [illegible]	23 5 1	10 16 0
5	[illegible]	[illegible]	0 0 0	21 8 2	18 18 3	23 7 2	24 10 2	27 8 [illegible]	26 12 1	22 10 2	24 1 0	24 1 3	25 17 2	21 12 3	0 0 0
6	[illegible]	[illegible]	0 [illegible] 0	22 10 1	21 5 1	24 7 2	21 12 1	22 14 0	28 15 0	24 4 1	21 12 1	26 8 0	22 13 2	22 13 2	0 0 0
7	[illegible]	Ayr	16 6 3	37 0 1	25 5 2	34 5 [illegible]	30 3 3	23 16 1	40 7 6	24 18 1	27 0 2	39 6 3	39 0 1	38 [illegible] 0	20 0* 0
8	[illegible]	Dumfries	11 4 2	38 [illegible] 3	26 4 1	23 1 1	24 10 0	32 2 2	28 16 0	30 10 3	30 10 1	31 11 1	25 18 2	28 13 1	11 4 2
9	[illegible]	[illegible]	9 15 [illegible]	26 5 3	25 5 3	25 12 1	27 10 3	21 7 1	28 2 3	24 10 3	24 7 1	25 7 1	23 12 1	24 5 3	0 15 0*
10	[illegible]	..	17 5 2	32 10 2	24 19 1	30 16 3	33 8 1	32 13 3	33 5 1	32 13 3	31 13 3	31 16 2	23 10 [illegible]	33 14 3	17 5 2*
11	[illegible]	Kirkcudbright,	16 13 3	15 5 3	15 14 2	18 4 0	16 8 2	21 [illegible] 0	21 11 2	21 11 2	16 18 1	16 18 0	19 2 2	18 14 2	12 10 1
12	[illegible]	Lanark,	3 10 0	18 5 0	13 0 [illegible]	18 5 0	23 10 [illegible]	28 7 1	26 17 3	24 4 1	20 18 1	19 17 0	22 2 2	23 16 3	3 11 2
13	[illegible]	..	25 4 0	27 [illegible] 0	31 2 0	37 3 0	36 2 1	31 3 2	31 3 2	32 12 0	30 12 0	31 13 3	30 12 [illegible]	37 3 [illegible]	25 4 0*
14	[illegible]	[illegible]	1 9 0	21 [illegible] 2	22 8 0	22 16 [illegible]	20 8 0	20 [illegible] 0	23 8 0	27 13 2	25 8 0	27 14 3	22 5 2	15 3 2	1 5 0
15	[illegible]	[illegible]	16 [illegible] 0	22 6 0	23 [illegible] 0	21 10 0	22 10 [illegible]	22 [illegible] 0	23 5 [illegible]	23 10 [illegible]	22 0 0	24 0 0	20 10 0	28 5 [illegible]	17 0 0
16	[illegible]	..	16 0 3	27 [illegible] 0	25 7 0	28 10 1	28 5 3	27 16 [illegible]	28 12 0	27 16 [illegible]	28 6 3	24 15 3	28 4 0	28 6 3	12 17 0
17	[illegible]	[illegible]	16 0 0	23 5 0	11 15 [illegible]	23 15 [illegible]	25 5 0	22 [illegible] [illegible]	22 15 [illegible]	24 10 0	27 0 0	24 [illegible] 0	25 15 [illegible]	21 13 0	12 17 [illegible]
18	[illegible]	[illegible]	14 9 2	18 14 0	18 3 [illegible]	20 10 1	20 [illegible] 0	20 10 1	20 15 1	20 15 1	20 [illegible] 0	20 5 1	10 11 3	17 11 1	14 5 1
19	[illegible]	Stirling,	5 4 2	0 17 1	13 3 2	1[illegible] 5 3	12 0 1	13 1 3	16 18 1	14 10 1	12 9 2	12 15 1	10 12 1	11 [illegible] 0*	4 12 3
20	[illegible]	Wigtown,	27 5 0	25 15 [illegible]	24 [illegible] 0	23 10 0	27 5 0	34 [illegible] 0	34 5 0	34 15 [illegible]	30 5 0	31 5 0	30 15 0	29 10 0	26 15 0
	Totals,		215 10 0	455 12 2	416 16 1	472 4 2	494 18 2	506 11 [illegible]	512 8 0	490 8 0	475 11 1	494 0 0	480 14 1	490 13 3	232 1 3
	Averages,		10 15 2	22 13 2	20 16 3	23 12 1	24 14 3	25 [illegible] 2	25 12 2	24 10 2	23 15 2	24 14 0	24 0 3	24 10 3	11 12 1
	Increase per Acre over Averages of Unmanured Plots,			11 0 3	1 13 0	12 8 2	13 11 0	14 2 3	14 8 3	13 15 3	12 11 3	13 10 1	12 17 0	13 7 0	
	Cost of Manures per Acre,			£1 2 0	£1 0 0	£1 11 [illegible]	£1 13 0	£1 13 0	£1 17 0	£1 13 0	£1 11 0	£1 11 0	£1 14 0	£1 12 0	

* Estimated.

(a) Containing Citric Acid Soluble Phosphoric Acid equal to that contained in 3 cwts. Superphosphate.

(b) Containing ½ cwt. Sulphate of Ammonia.
(c) Containing Nitrogen equal to that contained in ½ cwt. Sulphate of Ammonia.

(d) Containing Nitrogen equal to that contained in ½ cwt. Nitrate of Soda.
(e) Containing Nitrogen equal to that applied to Plot 9.

* Estimated.

NAMES OF FARMERS, FARMS, AND COUNTIES IN WHICH THE EXPERIMENTS WERE CARRIED OUT, WITH THE NATURE OF THE SOILS AND VARIETIES GROWN

No.	Experimenter.	Name of Farm.	County.	Nature of Soil.	Variety grown.
1	Nicol Reid,	Glenember, Dalrymple,	Ayr,	Red till, blue clay subsoil,	Swedes.
2	Alex. C. Speirs,	Clachaig, Arran,	Bute,	Clayey loam,	"Monarch" Purple Top Swede.
3	Montgomery Smith,	Kildavaig, Ardlamont,	Bute,	Gravelly loam,	Sutton's "Queen" Swede.
4	Thos. M. Donaldson,	Sarkshields, Ecclefechan,	Dumfries,	Black topped above clay,	Purple Top Aberdeen Yellow.
5	James W. Farish,	Newton, Kirk-Fleming,	Dumfries,	Black loam,	Webb's "Buffalo" Swede.
6	D. W. Crichton,	Limekilns, Annan,	Dumfries,	Red croft soil,	Purple Top Swede.
7	H. W. B. Crawford,	Chapmanton, Castle-Douglas,	Kirkcudbright,	Light loam,	—
8	D. H. Williamson,	Sypland, Kirkcudbright,	Kirkcudbright,	Light sharp soil,	"Best of all" Swede.
9	Campbell Montgomery,	Compstonend, Twynholm,	Kirkcudbright,	Clay,	Swede.
10	George Bryson,	Boreland, Parton,	Kirkcudbright,	Red, sharp, stony,	Aberdeen Yellow.
11	James Barrie,	Mossplatt, Carstairs,	Lanark,	Loam on ragstone,	Jack's Purple Top.
12	William Martin,	West Dykes, Lanark,	Lanark,	Light,	Inch's Bronze Top.
13	James Barry,	Whiteshaw, Carluke,	Lanark,	Medium loam on boulder clay,	Sutton's "Favourite" Purple Top Aberdeen.
14	Robert Hamilton,	Pool, Carnwath,	Lanark,	Grey soil on clay,	Fosterton Hybride.
15	George Miller,	Templemill, Crieff,	Perth,	Sharp light,	"Best of all" Swede.
16	William Murray,	Chapelhill, Methven,	Perth,	Black loam,	Aberdeen Yellow.

OF EACH PLOT,
ANU

ot 5	Plot 11.		Plot 12.			Plot 13.		
te. in , in drill mm wt. da.	ate, in the drills, g. in the drills. e drills, 3 cwts. rogen, in the drills.		Superphosphate, in the drills, 3 cwts. (*a*) Basic Slag. in the drills. Kainit. in the drills. 3 cwts. (*c*) Lime Nitrogen, in the drills. Nitrate of Soda, top dressed, ½ cwt.			No Manure.		
oots	Roots per Acre		Yield of Roots per Acre.			Yield of Roots per Acre.		
wts.	cwts.	qrs.	tons.	cwts.	qrs.	tons.	cwts.	qrs.
5	16	2	20	10	1	14	10	3*
0	10	0	15	0	0	0	10	0*
19	9	2	26	0	2	15	12	0
14	...		27	15	3	9	15	3
5	5	3	26	7	1	12	15	0
5	14	3	26	6	2	16	11	2*
16	2	2	20	10	0	13	17	2*
14	14	1	16	12	2	8	2	1
0	15	0	14	0	0	4	0	2*
0	17	2	23	6	2	1	0	0*
10	12	3	34	12	1	17	6	0
4	13	0	26	4	0	6	2	2*
...	15	0	19	5	0	4	10	0*
15	5	0	26	15	3	18	1	2
8	11	2	19	2	3	1	14	1
19	15	2	18	6	2	4	1	2
18	18	2	360	15	2	148	11	0
1	13	1	22	11	0	9	5	3
15	7	2	13	5	1	...		
14	13	0	£1	12	0	...		

) Con
) Con

* Estimated

TABLE II.—SHEWING THE RESULTS OF EXPERIMENTS ON THE MANURING OF TURNIPS IN 1910. THE KINDS AND QUANTITIES OF MANURES APPLIED, THE WEIGHT OF PRODUCT OBTAINED ON EACH PLOT, THE COST OF THE MANURES AND THE INCREASES RESULTING IN THEIR APPLICATION.

No.	Name of Farm.	County.	Plot 1. No Manure. Yield per Acre.	Plot 2. Superphosphate in the drills 3 cwts. Kainit in the drills 3 cwts. Yield per Acre.	Plot 3. Superphosphate in the drills 3 cwts. Kainit in the drills 3 cwts. Nitrate of Soda dressed 1 cwt. Yield per Acre.	Plot 4. Superphosphate in the drills 3 cwts. Sulphate of Ammonia in the drills 1 cwt. Nitrate of Soda dressed 1 cwt. Yield per Acre.	Plot 5. Superphosphate in the drills 3 cwts. Nitrate of Soda dressed 1 cwt. Yield per Acre.	Plot 6. Superphosphate in the drills, 3 cwts. Kainit in the drills 3 cwts. Sulphate of Ammonia in the drills 1 cwt. Nitrate of Soda dressed 1 cwt. Yield per Acre.	Plot 7. Superphosphate in the drills 3 cwts. Kainit in the drills 3 cwts. Sulphate of Ammonia in the drills 1 cwt. Nitrate of Soda dressed 1 cwt. Yield per Acre.	Plot 8. Superphosphate in the drills 3 cwts. (a) Equivalent to the Kainit in the drills. Sulphate of Ammonia in the drills 1 cwt. (c) Nitrate of Lime top-dressed. Yield per Acre.	Plot 9. Superphosphate in the drills 3 cwts. (a) Equivalent to the Kainit in the drills. (c) Nitrate of Lime top-dressed. Yield per Acre.	Plot 10. Superphosphate in the drills 3 cwts. (a) Equivalent to the Kainit in the drills. (e) Nitrate of Lime top-dressed. Yield per Acre.	Plot 11. Superphosphate in the drills 3 cwts. Kainit in the drills 3 cwts. (e) Nitrate of Lime top-dressed. Yield per Acre.	Plot 12. Superphosphate in the drills 3 cwts. Kainit in the drills 3 cwts. Nitrate of Soda dressed 1 cwt. Sulphate of Ammonia 1 cwt. Nitrate of Lime top-dressed. Yield per Acre.	Plot 13. No Manure. Yield per Acre.
			Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.	Tons cwts qrs.
1	[illegible]	Ayr.	14 15 3	16 4 3	21 9 —	21 1 1	19 5 1	22 1 0	21 10 1	17 15 1	18 6 2	17 11 0	19 16 2	20 19 1	14 19 3*	
2	[illegible]	[illegible]	5 1 0*	17 [illegible]	13 [illegible] 0	18 [illegible] 1	16 0 0	18 1 1	23 [illegible] 0	20 5 0	17 0 0	16 10 0	19 16 0	15 1 0	0 10 0*	
3	[illegible]	..	15 12 0*	20 15 [illegible]	21 14 2	21 14 2	22 19 2	23 5 0	24 [illegible] 0	20 17 2	25 0 2	23 3 2	25 0 2	20 1 2	15 12 0	
4	[illegible]	Dumfries.	[illegible] 1 2	20 11 2	22 17 1	23 6 2	24 14 1	25 17 3	27 0 0	25 15 3	25 14 1	20 2 3	[illegible]	27 15 3	0 15 3	
5	[illegible]	..	12 15 0*	21 [illegible]	22 [illegible] 3	27 5 [illegible]	20 5 0	20 5 0	28 1 0	28 10 0	26 3 2	25 18 2	22 5 3	26 7 1	12 15 0	
6	[illegible]	..	16 11 2	28 5 2	20 5 [illegible]	26 14 3	28 5 2	27 1 0	28 5 2	27 0 0	27 0 0	28 5 2	24 14 3	26 0 2	10 11 2*	
7	[illegible]	Kirkcudbright.	13 17 2	15 1 1	15 18 3	15 18 3	19 16 1	15 17 2	19 1 0	16 19 1	19 13 3	19 13 3	21 2 2	20 10 0	13 17 2*	
8	[illegible]	..	4 18 1	13 12 2	13 13 1	19 7 3	15 14 0	15 17 2	15 17 3	14 [illegible] 3	15 7 3	16 14 3	16 14 1	16 12 2	8 2 1	
9	[illegible]	..	4 [illegible] 2	12 17 1	11 11 1	19 0 2	16 0 3	16 15 2	17 10 3	16 16 3	17 2 3	17 0 0	15 15 0	14 0 0	4 0 2*	
10	[illegible]	..	1 0 0*	18 0 0	20 0 0	18 0 0	25 0 0	23 15 0	23 15 0	23 5 0	23 0 0	22 11 1	23 17 2	23 0 2	1 0 0*	
11	[illegible]	Lanark.	12 19 2	34 12 1	28 [illegible] [illegible]	40 7 2	37 10 [illegible]	37 [illegible] 0	37 10 0	43 5 1	36 1 0	34 12 1	31 12 3	34 12 1	17 9 0	
12	[illegible]	..	6 2 2	24 12 1	25 5 3	25 8 1	27 4 3	27 [illegible] 0	28 7 [illegible]	26 3 2	24 14 1	24 13 0	24 13 0	26 4 0	6 2 2*	
13	[illegible]	..	4 [illegible] 0	15 10 0	18 0 0	19 [illegible] 0			19 15 0	17 0 0	15 15 0	16 10 0	18 15 0	19 5 [illegible]	4 10 0*	
14	[illegible]	..	22 19 2	28 12 2	25 2 2*	31 13 2	26 15 3	24 2 0	31 [illegible] 0	29 2 0	25 18 2	28 10 2	30 5 0	29 15 3	18 1 2	
15	[illegible]	Perth.	1 14 1	18 [illegible] 0	11 14 1	27 2 3	28 [illegible] 2	2 5 3	21 2 3	22 0 0	19 2 3	20 8 2	18 11 2	19 2 3	1 14 1	
16	[illegible]	..	7 18 1	12 14 2	12 [illegible] 3	18 14 3	16 19 1	19 11 0	18 14 1	17 12 0	20 7 3	21 11 0	22 15 2	18 6 2	4 1 2	
	Totals		148 11 0	312 15 1	310 16 0	399 7 3	345 18 3	351 1 0	379 5 1	372 14 0	358 14 1	359 19 1	339 18 2	399 15 2	148 11 0	
	Averages		9 5 3	19 11 0	19 8 2	23 1 3	23 1 1	23 8 2	23 14 0	23 0 0	22 8 2	22 9 3	22 13 1	22 11 0	9 5 3	
Increase over Average of Unmanured Plots.				10 5 1	10 2 3	13 16 0	13 15 2	14 2 3	13 8 1	14 0 1	13 2 3	13 4 0	13 7 2	13 5 1		
Cost of Manure per Acre.				£1 2 —	£1 7 0	£1 13 0	£1 14 0	£1 14 0	£1 19 0	£1 13 0	£1 11 0	£1 11 0	£1 13 0	£1 12 0		

*Estimated.

(a) Containing Oil, Acid Sector Phosphoric Acid equal to that contained in 3 cwts. Superphosphate.

(c) Containing Nitrogen equal to that contained in 1 cwt. Nitrate of Soda.

(e) Containing Nitrogen equal to that contained in 1 cwt. Sulphate of Ammonia.

(a) Containing Nitrogen equal to that contained in 3 cwts. Kainit.

(c) Containing Nitrogen equal to that applied to Plot 2.

*Estimated.

1910.

NAMES OF FARMERS, FARMS, AND COUNTIES IN WHICH THE EXPERIMENTS WERE CARRIED OUT, WITH THE NATURE OF THE SOILS AND VARIETIES GROWN.

No.	Experimenter.	Name of Farm.	County.	Nature of Soil.	Variety grown.
1	Andrew Ronald,	Dalmore, Southend,	Argyll,	Poor thin grey soil on red till,	Aberdeen Yellow.
2	James F. Hunter,	Machribeg, Campbeltown,	Argyll,	Strong clay,	Austin's "Eclipse."
3	Ronald Scott Ker,	Glenreasdell Mains, Kintyre,	Argyll,	Medium loam,	Drummond's Purple Top Swede.
4	Mr. Macpherson,	Blarchascaig, Appin,	Argyll,	Loam,	Swede.
5	Mr. Maclachlan,	Kinlochlaigh, Appin,	Argyll,	Loam,	Aberdeen Yellow.
6	James M'A. Downie,	Appin House, Appin,	Argyll,	Light loam,	Swede.
7	John Kirkpatrick,	Kerslochmuir, Dalry,	Ayr,	Black loam,	Purple Top Swede.
8	John Irving,	Coatston, Dunscore,	Dumfries,	Sharp sandy soil.	"Fosterton Hybrid."
9	Archibald Warrick,	Gilbrae, Ruthwell,	Dumfries,	Clay,	"Best of all" Swede.
10	George Wallace,	Newmains, Duncow,	Dumfries,	Holm land,	"Best of all" Swede.
11	R. Sloan,	Barbeth, New Abbey,	Kirkcudbright,	—	—
12	Charles M. Douglas,	Auchlochan, Lesmahagow,	Lanark,	—	—
13	James French,	Netherton, Crawfordjohn,	Lanark,	Gravelly,	Improved Aberdeen Yellow.
14	Thomas Dykes,	Whitelaw, Avondale,	Lanark,	Light gravelly.	Fosterton Hybrid.
15	Thomas Forsyth,	Stane, Shotts,	Lanark,	Black loam,	Sutton's "Favourite."
16	Thomas Young,	Brackenridge, Strathaven,	Lanark,	Light soil over whinstone,	Sutton's "Favourite."
17	James Thorburn,	Maidencots, Abington,	Lanark,	Light,	Inch's Bronze Top.
18	John Inch,	Howburn, Biggar,	Lanark,	Light,	Inch's Bronze Top.
19	E. H. Stanley Craig,	Ballagan, Strathblane,	Stirling,	Black loam,	Swede.
20	James Wallace.	Craiglemine,	Wigtown,	—	Webb's "Renown" Yellow.

T

UR EACH PLOT,

N

lot	t 11.		Plot 12.			Plot 13.		
ate g. i e di Am cwt oda	te, in the drills, in the drills. drills, 3 cwts. gen, in the drills.		Superphosphate, in the drills, 3 cwts. (*a*) Basic Slag, in the drills. Kainit, in the drills, 3 cwts. (*c*) Lime Nitrogen, in the drills. Nitrate of Soda, top dressed, ½ cwt.			No Manure.		
Roo	oots per Acre		Yield of Roots per Acre.			Yield of Roots per Acre.		
cw	cwts.	qrs.	tons.	cwts.	qrs.	tons.	cwts.	qrs.
1(	15	0	25	0	2	11	4	0*
(	9	0	32	1	0		...	
1(	8	2	15	0	0	12	17	1
1.	15	1	21	5	0	10	19	1*
	16	2	16	6	2	10	17	1
(	5	0	24	0	0	19	0	0
1(	0	0	18	10	0	9	5	0
	2	3	27	19	1	16	0	0*
	14	1	20	0	0	14	8	2*
	6	1	200	2	1	104	11	1
	16	1	22	4	3	13	1	2
1	14	3	9	3	1		...	
1	13	0	£1	12	0		...	

* Estimated.

TABLE 5.—SHOWING THE COMPLETE RESULTS OF EXPERIMENTS ON THE ORTHARD, ON TURNIPS, IN 1911. THE YIELDS OF MANURES APPLIED TO THE SAME PLOTS IN PREVIOUS YEARS ARE ALSO GIVEN.

No.	Nature of Crop	Variety	Plot 1. No Manure	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.	Plot 7.	Plot 8.	Plot 9.	Plot 10.	Plot 11.	Plot 12.	Plot 13. No Manure
	Kind and Quantity of Manure applied														
	Date of Sowing														
	Date of Singling														
	Date of Harvesting														
1	Turnips	Yel.	2 1 1	24 17 —	— — —	— — —	27 — —	— — —	27 — 1	28 4 —	27 3 3	2 — —	26 — —	1 — —	— — —
2	Hay		36 — 3	46 — 3	46 — 6	50 1 3	50 — —	50 — —	58 — 3	31 8 2	41 1 —	8 12 2	36 4 —	17 — 6	
3	Barley	Primus	17 28 1	11 14 1	11 2 —	3 14 —	17 1 —	— — 1	— 11 2	13 — —	13 1 2	18 11 2	16 8 2	13 — 3	— — 1
4	Potatoes		30 — —	29 — 3	28 — —	3 14 —	28 14 —	28 — 2	27 8 2	29 2 3	21 6 3	23 2 2	26 8 1	21 8 2	1 3 17
5	Mangel	Intermediate	42 19 1	25 — 1	26 — —	2 8 —	2 7 2	21 13 2	— 5 —	22 — —	22 13 1	21 2 3	21 12 —	16 — 2	13 17 1
6	Cabbage	Lazard	18 — —	33 — —	32 1 —	— — —	2 — —	24 — —	21 12 —	23 3 0	22 3 0	22 — —	23 — —	24 — 0	10 — —
7	Lucerne	Provence	12 — —	12 14 —	12 14 —	11 18 —	14 1 —	17 — 0	10 12 —	14 4 2	15 10 —	15 15 —	— — 0	18 10 —	— — —
8	Rape	Dwarf	10 — —	22 1 1	25 — —	25 — —	25 — —	25 8 2	28 8 2	28 — 3	28 8 2	28 17 1	25 2 3	27 10 1	16 — 0*
9	Mixed Herbage	..	14 8 2	17 — 0*	15 11 —	14 8 2	1 2 3	14 — —	10 5 3	10 2 3	— — —	20 8 3	21 11 1	— — —	14 8 2*
	Total		184 11 1	195 8 0	198 5 3	200 10 —	210 1 1	223 — 3	258 — —	265 8 1	214 15 3	217 7 3	214 6 1	156 7 1	54 1 1
	Average		18 1 2	21 14 3	22 — 3	23 5 2	24 — 1	24 10 3	23 2 1	22 16 2	23 17 1	24 3 0	23 10 1	22 4 3	13 1 2
	Increase over Average of Unmanured Plots			8 12 1	8 10 1	10 4 0	10 18 3	11 15 1	10 — 3	9 15 3	13 15 3	11 1 2	10 14 3	9 3 1	
	Cost of Manures per Acre			£1 2 0	£1 7 0	£1 13 0	£1 14 0	£1 14 0	£1 10 0	£1 13 0	£1 11 0	£1 11 0	£1 13 0	£1 12 0	

* Estimated.

a Containing Cotton Seed Cake, Rape Cake, Superphosphate, Artificial Potash Salts, Sulphate of Ammonia, and 10 cwts. Superphosphate.

b Containing Potash Salts, Superphosphate, Kainit, Nitrate of Soda, and that contributed by 1 cwt. Sulphate of Ammonia.

c Containing Nitrogen equal to that contributed by 1 cwt. Nitrate of Soda.

d Containing Nitrogen equal to that applied to Plot 7.

* Estimated.

TABLE VI.

1911.

NAMES OF FARMERS, FARMS, AND COUNTIES, IN WHICH THE EXPERIMENTS WERE CARRIED OUT, WITH THE NATURE OF THE SOILS AND VARIETIES GROWN.

No.	Experimenter.	Name of Farm.	County.	Nature of Soil.	Variety grown.
1	John Gray, M.R.C.V.S.,	Tongue, Tarbolton,	Ayr,	Medium loam.	"Clydesdale" Swede.
2	John Fyfe,	Holehouse, Kilbirnie,	Ayr,	Light gravelly,	"Magnum Bonum" Swede.
3	James N. Grierson,	Bengalhill, Locherbie,	Dumfries,	Sandy loam,	"Ideal" Purple Top Swede.
4	Gavin Hamilton,	Porterstown, Thornhill,	Dumfries,	Light red soil,	"Aberdeen Yellow."
5	James Picken,	Milton, Kirkcudbright,	Kirkcudbright,	Medium loam,	Tait's "Best of all."
6	Peter Campbell,	Cartland, Lanark,	Lanark,	Light poor soil,	Tweedside Yellow.
7	William Wilson,	Jaapston, Neilston,	Renfrew,	Gravel,	Bronze Top Swede.
8	William More,	Fourmerk, Kippen,	Stirling,	Red loam,	Garton's "Model" Swede.
9	Thomas Syme,	Middle Kerse, Kippen,	Stirling,	Wet loam,	Swede.

Bulletin No. 61.

The West of Scotland Agricultural College.

SCHOOL GARDENS:

GENERAL RECOMMENDATIONS

AND

SUGGESTIONS FOR CONDUCTING SCHOOL GARDENS.

BY

A. HOSKING

(Lecturer in Horticulture).

GLASGOW, 1913.

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Assistant,	Thos. Moffat.

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Clerk—Ellie A. Kirkwood. | Janitor—Andrew M'Cowatt.

INSTRUCTION IN HORTICULTURE.

TEACHERS' CLASSES.

During the months of July and August courses of instruction in School Gardening are given to Teachers in actual service. The Courses, which extend to four weeks, include lectures in Horticulture, Botany, and Chemistry, and practical instruction in School Gardening. The class meets daily, Mondays to Fridays, from 9 a.m. to 12 noon, and 1 p.m. to 4 p.m.

Further particulars regarding these classes may be obtained from the Secretary of the Agricultural College, or from the Director of Studies, Glasgow Provincial Committee for the Training of Teachers, Royal Technical College, Glasgow.

Teachers who contemplate attending one of these Courses are recommended to apply to their respective County Committees for payment of their travelling expenses and maintenance under par. 17 (5) b of the Education (Scotland) Act, 1908.

FORMATION OF SCHOOL GARDENS.

The services of Mr. Hosking are available, free of expense, to School Boards and Teachers contemplating the formation of School Gardens.

Members of School Boards and others desiring his advice and assistance are requested to communicate with the Secretary—Mr. John Cuthbertson, National Bank Buildings, Kilmarnock.

EXTENSION LECTURES AND DEMONSTRATIONS.

The Governors are prepared to consider applications for the services of the Lecturer in Horticulture, not only for the delivery of Lectures, but also for visits to orchards and gardens, with a view to giving advice as to their improvement.

The services of the Lecturer are given free, and the Governors pay the whole of the Lecturer's travelling and other personal expenses.

Admission to the Lectures and Demonstrations should be free.

The Local Committee is expected to make all necessary arrangements for the Lectures and Demonstrations, including advertising, use of Schoolroom or Hall, &c.

Early application should be made for the services of the Lecturer, and the subjects may be selected from the Syllabus on page 62.

PREFACE.

NEARLY four years have elapsed since Bulletin No. 49, on the Teaching of Gardening in Public Elementary Schools and the Formation of School Gardens—copies of which may still be obtained on application to the Secretary—was first issued. At that date there were probably less than 6 schools in the West of Scotland at which Gardening was being taught, while at the present time (March, 1913) there are about 140 school gardens in the College area. It has been suggested that further particulars and suggestions for conducting School Gardening Classes would be of service to School Boards and Teachers. In view of this the following Bulletin has been prepared in the hope that it may prove of some benefit to those concerned.

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CODE OF REGULATIONS *RE* SCHOOL GARDENS.

Scotch Education Department.

Code of Regulations for Day Schools, 1912, Article 21.

When a scheme of instruction in agriculture or horticulture for the schools of any district has been prepared by the authorities of a recognised agricultural college, with the approval of the department, the instruction under this head must be in general conformity with the said scheme, and subject to such supervision by officers of the college, in conjunction with H.M. Inspector, as the department may direct.

Grants for attendance at a course of practical instruction in agriculture or horticulture at the rate of 8s. 4d. per 100 hours attendance for pupils over 12 years of age may be made when it is shown:—

That the accommodation provided for the purpose is sufficient and suitable;

That the lessons are given by properly qualified instructors, and are, as a rule, of not less than $1\frac{1}{2}$ hours duration;

That lessons for which these grants are claimed consist mainly of individual work on the part of the pupils, properly directed and supervised, and in general accordance with a scheme of work determined beforehand. No payment will be made on account of attendances of pupils at any of these courses of instruction for more than one year, unless the scheme of work provides for different and more advanced exercises in each successive year;

That, as a rule, not more than 20 pupils are taken at a time for a practice lesson by any one teacher.

REGULATIONS AND SUGGESTIONS PROPOSED BY THE GOVERNORS OF THE WEST OF SCOTLAND AGRICULTURAL COLLEGE.

1. School Boards making application for a class in School Gardening should fill in a form—obtainable from the Secretary of the Agricultural College—giving particulars as to the amount of land available for the school garden, number of pupils likely to form the class, &c. On receipt of this completed form by the College, a member of the staff will visit the school and confer with the School Board and teacher in order to ascertain if the proposed land is suitable, and furnish any information desired as to laying out, &c. A Scheme of Work (see page 51) is then prepared by the teacher and forwarded to H.M. Inspector for that district.

2. Instruction in School Gardening may only be given by teachers who possess a certificate in that or an allied subject—such as certificates granted by the Provincial Committees for the Training of Teachers, Agricultural Colleges, Horticultural Colleges, or other approved bodies—unless they are specially approved by the Governors of an Agricultural College, on the recommendation of the Instructor in Horticulture.

3. All School Gardens in conformity with the scheme approved by the department will be inspected at least once a year—from April to October—by a member of the College staff, in order to ascertain whether the garden has been laid out in a satisfactory manner, kept neat and clean, and that a fairly representative collection of vegetables (at least 15 kinds), herbs (at least 6 kinds), fruit trees, and flowers are grown, and an adequate set of tools (according to the size of the garden and the number of pupils) provided and kept in good condition.

4. The payment of grants will, as a rule, depend upon a satisfactory report being submitted to the Education Department.

5. When, owing to scarcity of land, or for other reasons, a portion of a Schoolhouse Garden is used as a School Garden, it should be regarded as part of the school premises and not as the teacher's garden. School Boards, however, might consider whether

the teacher should receive some compensation for the loss to his garden.

The plots are usually one pole or more in area, and are each worked by one pupil, or, for convenience, two pupils may work together, but not more than two should work together on one plot.

There is a tendency on the part of some School Boards to regard School Gardening merely as a means of earning grants—thus saving the rates—and, for this purpose, as many pupils as possible are placed in the gardening class, irrespective of the amount of land available. There should, however, be some sort of minimum as regards the amount of land provided per pupil. It appears desirable that the area of land should be at least sufficient to allow half a pole per pupil, with an extra plot or plots—comprising not less than three poles—to serve as a nursery garden, seed bed, and for herbs, miscellaneous plants, agricultural plants, and, if possible, some fruit bushes.

If, in addition to the School Garden, there is a Schoolhouse Garden in which fruit trees and bushes, shrubs, and flowers are cultivated, the pupils should be encouraged to take an interest in their proper management.

6. Both boys and girls may take part in gardening.

7. Pupils in the Supplementary Class, and those over twelve years of age, are eligible for grants. For the sake of convenience other pupils may take part in gardening, but grants are not paid in respect to these.

8. One or more lessons may be given each week. The duration of each lesson should be from one to two hours; the number of hours per week to be from one and a-half to four. The day and hour of gardening should be arranged to suit the convenience of the work of the school generally.

9. A special register should be kept for recording the attendance of pupils at a gardening class.

10. If the weather at the hour appointed for gardening be unsuitable, the lesson may be postponed until the succeeding fine day, a note to this effect being entered in the log book.

During winter theoretical lessons may be given in the schoolroom. These lessons may be on the lines suggested in the syllabuses of instruction in the principles and practice of horticulture, pp. 59-63.

11. Note Books for recording work done and observations made should be kept by the pupils (see page 53).

12. The tools provided should comprise a set for each plot, as follows :—

1 Spade.
1 Digging Fork.
1 Rake.
1 Draw Hoe.
1 Dutch Hoe.
1 Trowel.
1 Handfork.
1 Dibber.

For the common use of the class the following should be provided :—

1 Wheelbarrow.
1 Watering Pot.
1-2 Garden Lines, with Reels complete.
2 Measuring Rods (4 feet long).
1 Garden Basket.

Other tools may also be required according to circumstances.

A tool-house for the proper storage of the tools should be provided, unless a suitable place is already available for this purpose.

13. The School Board may dispose of the produce, either by sale—the proceeds being devoted to the maintenance of the garden, or given as prizes for the best-kept plots and note books —or by utilising it in connection with the soup kitchen or cookery classes. More generally, however, the produce is given to the pupils cultivating the plots. This seems on the whole the most satisfactory method of disposing of the produce grown on the individual plots.

SCHEMES OF WORK.*

The following suggestions are given with a view to aiding teachers in drawing up a scheme of work for approval by H.M. Inspector. Each scheme should give particulars of the following :—

1. Name of school with date of application.

2. Name of teacher who will conduct the class.

3. Certificates or any special qualifications for gardening, *i.e.*, in botany, nature study, agriculture, or horticulture.

4. Land available :—

   (*a*) Area.
   (*b*) Aspect.
   (*c*) Kind of soil.
   (*d*) Distance from School.
   (*e*) Whether schoolhouse garden, portion of playground, or special plot.
   (*f*) Shelter.
   (*g*) Protection from trespass and cattle.

5. Method of laying out the land :—

   (*a*) Whether as a common plot on which all the pupils work in co-operation, in which case state any special feature, *i.e.*, fruit plot, herb plot, seed plot, experiment plot, etc.

   (*b*) Or divided into plots; if so, give the number of plots with their area, and state if a portion is set apart for seed-beds, fruit, etc.

   (*c*) Or whether as a combination of common plot and individual plot.

6. Nature of the crops to be grown, giving a list of the vegetables, herbs, and fruits, and stating whether, in addition, flowers are cultivated.

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* The suggestions on pp. 51-59 are adapted from the author's book on "School Gardening, with a Guide to Horticulture" (University Tutorial Press, price 3s. 6d.), by permission of the publishers.

7. Number of pupils available for gardening (not to exceed 20 for one teacher at any lesson in Scotland); whether they work singly, in pairs, or in co-operation, and how the attendance is to be kept.

8. Number of hours and lessons per week devoted to this subject.

9. General equipment of the garden, viz., a list of tools, giving number of spades, forks, rakes, hoes, etc., and stating whether there is a wheelbarrow, tool-shed, and a garden frame.

10. State how the produce is to be disposed of, *i.e.*, whether given to the pupils, sold, or used in connection with the cookery classes.

11. Describe how the pupils are to record their work and observations.

12. State how it is proposed to provide for those pupils taking gardening a second or a third year.

Example.—In the first year they may work their own plots; in the second or third year they may work on the demonstration plot and fruit plot, and take part in propagation, manuring, and any experiments conducted, or additional practice may be given on the individual plots.

13. A sketch or plan of the proposed garden should be submitted with the scheme.

14. Describe the practical work to be performed, *i.e.*, digging, hoeing, mulching, manuring, seed sowing, transplanting, pruning, propagation, etc., and also the proper care and use of the various garden tools provided.

15. Correlation with other subjects, *i.e.*, showing how it is proposed to correlate school gardening with such subjects as—

Composition, arithmetic, mensuration, drawing, nature study, cookery, or woodwork.

16. Winter work, *i.e.*, what is proposed to be done during the winter months. (See notes on winter work, page 55.)

NOTE BOOKS KEPT BY THE PUPILS.

The Scotch Education Department attach considerable importance to the correct keeping of garden notes by the scholars attending the classes, and the following suggestions have been drawn up with a view to providing guidance where a note book on similar lines is not already in use. The notes should be made in a good exercise book from the rough working notes entered by the scholars on the spot in a small penny note book. The writing up of the permanent notes might be regarded as a composition lesson. Care should be taken that only notes on work which the pupil has actually done should be recorded.

The note book should be prepared on the following broad lines, and the entries should, as far as possible, be made while the work is still fresh in the minds of the pupils :—

(*a*) Particulars of the school garden.

(1) Name of School.....

(2) Parish..... (3) County.....

(4) Name of pupil.....

(5) Age last birthday..... (6) Class..... .....

(7) Situation of garden.....

(8) Aspect.....

(9) Nature of gradient (if any).....

(10) Nature of the soil to a depth of one foot .....

Nature of the subsoil.....

(11) Area of the garden.....
length.....width.....

(12) Area of pupil's own plot.....
length.....,....width.....

(*b*) Plan of the garden, drawn to scale, showing all the plots.

(*c*) Plan of the pupil's plot, showing manner of cropping.

(*d*) Plans of fruit plot, herb plot, or any other feature of the garden.

(*e*) Particulars of crops grown.

A double page of the note book may be set apart for this purpose, and columns ruled to contain particulars of all the crops grown. The following examples indicate the necessary information which should be furnished:—

Name of Crop.	Variety.	Date of sowing or planting.	Date when seedlings appeared.	Depth of sowing.	Date of transplanting or thinning.	Length of row.	Distance apart.	Date when crops matured.	Number of weeks taken to nature.	Yield of crop.	Estimated value of the produce.	Remarks.
											s. *d.*	
Cauliflower	Early London	April 8	May 1	1 in.	June 3	9 ft.	18 in.	Aug. 4	17 wks.	4 heads	0 6	Two plants destroyed by cabbage root maggot.
Carrot -	Long Red Surrey	,, 29	,, 20	1 ,,	,, 19	,,	6 ,,	,, 15	15 ,,	18 good roots =5 lb.	0 5	The seedlings were dusted with soot at intervals.
Potato -	The Factor	March 29	,, 2	5 ,,	...	,,	18 ,,	Sept. 19	25 ,,	18 lb.	0 9	The tops slightly damaged by frost on May 6th.

SUGGESTIONS FOR AUTUMN AND WINTER WORK.

Teachers taking up School Gardening are sometimes at a loss to know what to do in connection with the Gardening class during the winter months.

The following information will furnish some guide as to the nature of the outdoor work possible in the autumn and winter, when the weather permits.

Propagation of Bedding Plants.—Cuttings of bedding plants may be taken and inserted in sandy soil in a frame, which will require to be covered with mats in severe weather.

Preservation of Tender Plants during Winter.—Dahlia tubers, begonia tubers, and gladioli corms, may be lifted, dried, and stored in a frost-proof place.

Roots for Winter Use.—Carrots, beetroot, and turnips may be lifted and stored in a cellar or shed, the roots being covered with sand, dry ashes, or soil.

Potatoes for Planting.—The potato crop may be lifted, and medium-sized tubers selected for planting the following year; these may be placed in a frost-proof shed, where light can reach them to encourage strong, sturdy sprouts.

Earthing Celery and Leeks.—The earthing-up of celery and leeks may be completed when the weather is dry.

Cleaning Operations.—All dead and decaying stems, leaves, flowers, &c., may be removed, and the general cleaning up of the garden attended to.

Soil Preparation and Manuring.—The digging, double digging, trenching, or ridging of all vacant ground may be proceeded with, and manure or soil from a compost heap added at the same time.

Wheeling Manure, Soil, &c.—Advantage should be taken of hard frosty weather to do all the necessary wheeling of manure, soil, leaves, &c., required in the garden.

Planting Biennials. — Wallflowers, forget-me-nots, double daisies, foxgloves, Canterbury bells, and other hardy biennial plants may be planted for spring and early summer flowering.

Purchase and Planting of Bulbs.—Bulbs, corms, and tubers may be purchased, some planted in borders or beds and others in pots or boxes, for early flowering.

Increasing Gooseberry and Currant Bushes.—Cuttings of gooseberry and currant bushes may now be taken, prepared, and inserted in the open ground for increasing the stock. Strong one-year-old shoots should be selected.

Stocks for Budding and Grafting. — Wild briars may be collected from the hedgerows or thickets (coppice) and planted in the garden for budding garden roses the following summer. Stocks for budding or grafting apples, pears, plums, or roses may be purchased from the nursery for practice in budding and grafting. These are sold at a cheap rate—8s. to 12s. per 100, according to variety and size; or seeds may be sown for raising a supply of these stocks.

Planting Roses, Fruit Trees, etc.—Trees and shrubs, including roses and fruit trees, may be purchased and planted during autumn or spring, but not, as a rule, in mid-winter unless the weather is very mild.

Pruning.—Fruit trees may be pruned and thinned; vigorous growing specimens may also require root pruning to check rank growth and induce fruitfulness.

Raspberry Canes and Strawberry Runners.—The old fruiting canes of raspberries and the surplus runners of strawberries may be removed from the plants, and the ground hoed or otherwise cleaned.

Staking Trees.—The staking of standard and half-standard trees may require attention to prevent damage by gales. Newly planted trees of this description require support to facilitate rooting.

Making Leaf-mould.—Fallen leaves of trees may be collected, placed in a heap, and turned once or twice to hasten decomposition and prevent rapid heating. When well decayed these make

good leaf-mould, either for pot plants or for improving garden soils. Oak, beech, elm, or Spanish chestnut, being of a hard texture, make the best leaf-mould.

Preparation of Potting Loam.—Grass sods or turves may be procured from an old pasture or from the road-side and stacked in a heap, grass side downwards. These, when well rotted, form good potting loam. The more fibrous the loam the more valuable it becomes. Sometimes it is possible to obtain good turfy loam where new buildings are about to be erected.

Lessons on Soils.—Tillage operations such as digging, trenching, ridging, draining, hoeing, &c., should be practised and thoroughly explained.

THE COST OF ESTABLISHING A SCHOOL GARDEN.

The initial cost of establishing a school garden will vary according to the system of laying out, the condition of the land, the number of pupils available for gardening, and the requirements of the Local Education Authority. Below will be found details of the cost of tools, &c., for a garden of 10 plots, sufficient for ten to twenty pupils :—

	£	s.	d.
10 Spades, No. 1, 2s. each, ...	1	0	0
10 Digging Forks, 4 pronged, 2s. each, ...	1	0	0
10 Draw Hoes, 6 inch, handled, 1s. each, ...		10	0
10 Dutch Hoes, $5\frac{1}{2}$ inch, handled, 1s. each, ...		10	0
10 Rakes, handled, 1s. each, ...		10	0
10 Trowels, 6d. each, ...		5	0
10 Hand Forks, 6d. each, ...		5	0
10 Small Dibbers, 2d. each, ...		1	8
2 Birch Brooms, handled, ...		1	0
1 Billhook, ...		2	0
1 Watering Pot, ...		2	4
1 Garden Line with reel complete, ...		2	0
3 Measuring Rods, 4 feet long, ...		1	0
1 Wheelbarrow, ...	1	0	0
1 Large Rake, about		2	6
Carry forward, ...	£5	12	6

Brought forward, ...	£5	12	6
Pea Sticks, or wire netting for peas, say ...		5	0
Manure, say		14	0
Seeds, Tubers, Wood Labels, &c., about ...		13	6
Sussex or Trug Basket, about		1	6
Spray Syringe, ...		8	6
Fruit Trees, say	1	1	6
24 Hardy Plants or Herbs, say		6	0
Tool and Potting Shed, £3 to £10, according to size, say	5	0	0
Total, ...	£14	2	6

It will be seen from the foregoing statement that a sum of about £14 represents the initial cost of equipment for a school garden, and of carrying it on for the first year. In many cases, however, a much smaller sum will suffice.

But, on the other hand, where draining, levelling, or trenching are necessary, and a charge made also for rent of the land, then the cost will be slightly increased.

Where there are two classes in school gardening, then, for the sake of economy, one set of tools will suffice for both, but a double set of plots should be provided.

A garden frame will prove useful in the spring for rearing seedlings of leeks, celery, onions, cauliflowers, tender annuals, &c.; for growing tomatoes or cucumbers in summer, and for preserving tender plants through the winter.

A ready-made frame will cost 20s. to 60s. according to size and quality. But when there is a joinery class a suitable frame may easily be made by the pupils. A small greenhouse finds a place in some gardens, but is not absolutely necessary.

It is desirable that the tool-shed be provided with a bench for use during wet days. A similar bench or shelf on the outside of the shed will be found convenient for label writing, sorting, &c., during fine weather.

Fruit Trees and Bushes.—The introduction of a few fruit trees and bushes serves the desirable purpose of demonstrating proper methods of planting, pruning, and training, in addition to propagation.

In addition to the initial cost, the annual outlay after the first year will be about £2 10s., made up as follows:—Manure, 14s.; seeds, 13s. 6d.; pea sticks, 5s.; painting, repairs, and breakages, 14s.; plants, 3s. 6d.

County Committees may make grants towards the initial cost to schools taking up this subject.

SUGGESTED SYLLABUS OF INSTRUCTION IN THE ELEMENTARY PRINCIPLES OF HORTICULTURE.

Winter Session.—1st Year.

I.—*Plants*—Examination of typical plants common in the garden.

A—*Roots*—Their forms; their functions; how the root branches and absorbs material from the soil; root hairs and how they work.

B—*Shoots*—(1) *Stem*—Its functions and growth; branching and hardening with age; adaptations of stems for special purposes, *e.g.*, creeping and twining.

(2) *Leaves*—Their functions; veins and pores; adaptation of leaves for special purposes, *e.g.*, climbing.

C—*Vegetative parts of the plant as a whole*—Roots absorb water and minerals from the soil; passage of materials from root through stem into leaf; escape of water vapour from leaf; entrance of air from the atmosphere through the leaf pores; distribution of air throughout the plant; action of sunlight upon the contents of the green parts; food formation.

D—*Reproductive parts*—Flower; fruit; seed; the part of the plant which becomes the seed and how the embryo is formed in its interior; common seeds of garden and farm, *e.g.*, bean, mustard, grain of wheat; vitality of seeds; natural methods of seed distribution and special adaptations for same, *e.g.*, thistledown, &c.

E—*Germination of the seed on soil and on blotting paper*—Part played by moisture, air, and heat; construction of the seedling.

F—*Duration of Plants*—Annuals, biennials, perennials.

G—*Parts of the plant used as food stores—E.g.*, in turnips, carrots, potatoes, onions, cabbages, &c.

II.—*Water*—In its three forms; its presence in air; formation and deposition of rain, dew, and fog; rainfall and its measurement; its solvent action illustrated by total solids in water; different kinds of water; chemical composition of water shown by electrolysis or burning of hydrogen gas; elements and compounds.

III.—*Air*—A mixture of colourless gases; its weight measured by barometer; the action of heat; air currents; ventilation; measurement of temperature.

Chemical Properties—Illustrate by a burning candle that it supports combustion, producing a change shown by drawing products of combustion through lime water.

Constituents—Nitrogen and oxygen chiefly; also some carbon-dioxide, water vapour, and very small amounts of other gases.

Oxygen—Supports combustion better than air; heat evolved; chemical changes; products of combustion; oxides; its relation to the living organism.

Nitrogen—Does not support combustion; its relation to plant life.

Carbon-dioxide—A compound formed in combustion and in respiration; its properties; action on lime water.

Meteorological Records and Charts.

IV.—*Limestone*—Lime burning; quick lime; slaked lime; effect of exposure to air.

V.—*Acids, Bases, and Salts*—Their meaning and properties; action on test papers; examples of the more common—

(1) *Acids*—Sulphuric, nitric, phosphoric, hydrochloric, carbonic, &c.

(2) *Bases*—Lime, ammonia, potash, magnesia, iron oxide, &c.

(3) *Salts*—Nitrates, phosphates, sulphates, chlorides, carbonates, &c.

VI.—*The Soil*—Formation; mechanical analysis; sand and clay; organic matter and micro-organisms; chalk; water; air; typical soils, sands, loams, clays, chalks, marshes, peats, and bogs; soil constituents connected with plant nutrition; solvent action of soil water and of plant roots; the soil as a store-house of plant food; plant food taken up in solution; the solubility of the plant food in the soil; effect of tillage operations on the water and air in soils; the replacement of plant food removed from the soil, manuring.

VII.—*Nutrition of Plants from the Atmosphere*—The green leaf, external form of various leaves; position of leaves to secure light; upper and lower surface of leaves; green leaves necessary for plant growth; leaves manufacture starch as one form of plant food; iodine as a test for starch in grain of cereals, potato tubers, &c., and in the leaf; starch formed in light and disappears in darkness; growth of growing plants in darkness; greened and ungreened potato tubers; carbon-dioxide in atmosphere necessary for production of starch.

VIII.—*Water Culture and its Lessons*—Essential constituents for plant life: nitrates, phosphates and sulphates of potassium, calcium, magnesium, and iron.

IX.—*Composition of Plants*—Water as shown by drying; organic matter and ash (mineral matter) as shown by burning.

SUGGESTED SYLLABUS OF INSTRUCTION IN THE OPERATIONS AND PRACTICE OF HORTICULTURE.

Winter Session, 2nd Year.

Soils—Origin; formation; classification; properties of each kind.

Tillage Operations—Draining; digging; trenching; hoeing; raking; earthing up; weeding; watering; mulching; seed sowing; thinning; transplanting.

Manures—Natural and artificial; classification; properties of each.

Manuring—How and when to apply manures for garden crops.

Rotation of Garden Crops—Intercropping; successional cropping.

Grouping of cultivated plants for garden purposes—Trees; shrubs; herbaceous plants (annuals, biennials, and perennials); vegetables; salads; culinary herbs; flowers; fruits.

Classification of vegetables and fruit-bearing crops according to their families, and to the portion used as food.

Cultivation of Vegetables—Root crops; tubers; bulbs; green crops; pod-bearing crops; salads; herbs.

Cultivation of Hardy Fruit—Apples; pears; plums; cherries; gooseberries; currants; strawberries; raspberries; blackberries (brambles); loganberries.

Cultivation of tomatoes, cucumbers, and vegetable marrows.

Cultivation of Hardy Flowers—Herbaceous perennials; biennials; annuals.

Cultivation of roses, carnations, sweet peas, and other florists' flowers.

Cultivation of ferns, greenhouse, and window plants.

Principles of Pruning—Fruit trees and bushes; roses and other shrubs.

Plant Propagation—Seeds; cuttings; layering; budding; grafting.

Diseases and Insect Pests—Common diseases and insect pests of fruit, flowers, and vegetables.

Improvement of cultivated plants by selection, cross-breeding, and hybridisation.

Fruit and Vegetable Bottling—For use in winter.

List of Common Trees and Shrubs arranged according to their Botanical Relationship (Natural Order).

* Indicates native of Britain.

Common Name.	Botanical Name.	Natural Order.
Tulip-tree	Liriodendron tulipifera	Magnoliaceae
Yulan or Magnolia	Magnolia conspicua	,,
Holly-leaved Barberry	Berberis Aquifolium	Berberidaceae
Darwin's ,,	,, Darwinii	,,
Narrow-leaved ,,	,, stenophylla	,,
*Common ,,	,, vulgaris	,,
*Tamarisk	Tamarix gallica	Tamaricaceae
*Small-leaved Lime-tree	Tilia cordata	Tiliaceae
*Large ,, ,,	,, platyphyllos	,,
*Common ,,	,, vulgaris	,,
Tree-of-Heaven	Ailanthus glandulosa	Simarubaceae
*Common Holly	Ilex Aquifolium	Aquifoliaceae
*Common Spindle-tree	Euonymus europaeus	Celastraceae
Japanese ,,	,, japonicus	,,
*Common Buckthorn	Rhamnus cathartica	Rhamnaceae
*Alder ,,	,, Frangula	,,
*Horse Chestnut	Aesculus Hippocastanum	Sapindaceae
Red Buckeye	,, Pavia	,,
*Hedge Maple or Small-leaved Maple	Acer campestre	,,
Norway Maple	,, platanoides	,,
*Sycamore, Scotch Plane, or False Plane-tree	,, Pseudo-platanus	,,
Judas-tree	Cercis Siliquastrum	Leguminosae
Early-flowering Broom	Cytisus praecox	,,
*Common ,,	,, scoparius	,,
*Dyers' Greenweed	Genista tinctoria	,,
Common Laburnum	Laburnum vulgare	,,
False Acacia or Locust-tree	Robinia Pseudacacia	,,
*Furze, Whin, or Gorse	Ulex europaeus	,,
Grape-flower Vine	Wistaria chinensis	,,
*Common Cotoneaster	Cotoneaster integerrima (C. vulgaris)	Rosaceae
Horizontal ,,	,, horizontalis	,,
Small-leaved ,,	,, microphylla	,,
*Whitethorn or Hawthorn	Crataegus Oxyacantha	,,
Firethorn	,, Pyracantha (var. Laelandi)	,,
*Shrubby Cinquefoil	Potentilla fruticosa	,,
*Gean or Mazzard Cherry	Prunus Avium	,,
*Wild Cherry	,, Cerasus	,,
*Wild Plum and Damson	,, communis (P. domestica)	,,
*Bullace	,, insititia	,,
Cherry Laurel	,, Laurocerasus	,,
Portugal ,,	,, lusitanica	,,
*Birdcherry	,, Padus	,,
Purple-leaved Plum	,, Pissardi	,,

Common Name.	Botanical Name.	Natural Order.
Sloe or Blackthorn	Prunus spinosa	Rosaceae
Three-lobed Plum	,, triloba	,,
White Beam-tree	Pyrus Aria	,,
Mountain Ash or Rowan-tree	,, Aucuparia	,,
Wild Pear-tree	,, communis	,,
Free-flowering Pyrus	,, floribunda	,,
Medlar	,, germanica	,,
Bastard Mountain Ash	,, hybrida	,,
Lobed-leaved White Beam-tree	,, intermedia	,,
Japanese Quince	,, japonica	,,
Wild Apple-tree or Crab-apple	,, Malus	,,
Broad-leaved Beam-tree	,, rotundifolia	,,
True Service-tree	,, Sorbus	,,
Wild ,,	,, Torminalis	,,
Trailing Dog Rose	Rosa arvensis	,,
Dog Rose	,, canina	,,
Irish Burnet Rose	,, hibernica	,,
Sweetbriar or Eglantine Rose	,, rubiginosa	,,
Scotch Rose or Common Burnet Rose	,, spinosissima	,,
	(many other species and varieties)	
Deutzia	Deutzia crenata	Saxifragaceae
Escallonia	Escallonia macrantha	,,
Mock-orange	Philadelphus coronarius	,,
Mountain Currant	Ribes alpinum	,,
Gooseberry	,, Grossularia	,,
Black Currant	,, nigrum	,,
Red ,,	,, rubrum	,,
Flowering Currant	,, sanguineum	,,
Ivy	Hedera Helix	Araliaceae
Japanese Laurel	Aucuba japonica	Cornaceae
Dogwood or Wild Cornel	Cornus sanguinea	,,
Bush Honeysuckle	Diervilla florida	Caprifoliaceae
Perfoliate Woodbine	Lonicera Caprifolium	,,
Common Honeysuckle	,, Periclymenum	,,
Upright Fly ,,	,, Xylosteum	,,
Common Elder	Sambucus nigra	,,
Snowberry	Symphoricarpus racemosus	,,
Wayfaring-tree	Viburnum Lantana	,,
Guelder Rose	,, Opulus	,,
Laurustinus	,, Tinus	,,
Marsh Cistus or Wild Rosemary	Andromeda polifolia	Ericaceae
Strawberry-tree	Arbutus Unedo	,,
Rhododendron	Rhododendron, several species	,,
Common Ash	Fraxinus excelsior	Oleaceae
Yellow Jessamine	Jasminum nudiflorum	,,
Sweet ,,	,, officinale	,,
Oval-leaved Privet	Ligustrum ovalifolium	,,
Common ,,	,, vulgare	,,
Common Lilac	Syringa vulgaris	,,
Tea-tree	Lycium chinense	Solanaceae
Bay Laurel or Sweet Bay	Laurus nobilis	Lauraceae

Common Name.	Botanical Name.	Natural Order.
*Spurge Laurel	Daphne Laureola	Thymeleaceae
*Mezereon	,, Mezereum	,,
Golden Bell	Forsythia suspensa	,,
*Sea Buckthorn	Hippophae rhamnoides	Elaeagnaceae
*Mistletoe	Viscum album	Loranthaceae
*Box-tree	Buxus sempervirens	Euphorbiaceae
*English Elm	Ulmus campestris	Urticaceae
*Wych or Scotch Elm	,, glabra (montana, Stokes)	,,
*Plott's Elm	,, minor	,,
*Smooth-leaved Elm	,, nitens	,,
*Small-leaved ,,	,, sativa	,,
*Cornish ,,	,, stricta	,,
London Plane	Platanus acerifolia	Platanaceae
Western Plane or Button Wood	,, occidentalis	,,
Oriental Plane	,, orientalis	,,
Common Walnut	Juglans regia	Juglandaceae
*Bog Myrtle or Sweet Gale	Myrica Gale	Myricaceae
*Common Alder	Alnus glutinosa	Cupuliferae
*Common Birch	Betula alba	,,
*White ,,	,, ,, var. pubescens	,,
*Dwarf ,,	,, nana	,,
*Common Hornbeam	Carpinus Betulus	,,
*Spanish or Sweet Chestnut	Castanea sativa	,,
*Common Hazel, Cobnut, or Filbert	Corylus Avellana	,,
*Common Beech	Fagus sylvatica	,,
Turkey Oak	Quercus Cerris	,,
Holm Oak or Evergreen Oak	,, Ilex	,,
*Common Oak	,, pedunculata	,,
*Sessile-fruited Oak	,, sessiliflora	,,
Cork Oak	,, Suber	,,
*Common White Willow	Salix alba	Salicaceae
*Blue Willow	,, ,, var. caerulea	,,
*Golden Willow or Osier	,, ,, ,, vitellina	,,
*Round-eared Willow	,, aurita	,,
*Goat Willow or Common Sallow	,, Caprea	,,
Kilmarnock Weeping Willow	,, ,, var. pendula	,,
*Crack Willow or Withy	,, fragilis	,,
*Downy Mountain Willow	,, Lapponum	,,
*Bay-leaved Willow	,, pentandra	,,
*Bitter Purple Willow or Osier	,, purpurea	,,
*Dwarf or Creeping Willow	,, repens	,,
*Netted-leaved Willow	,, reticulata	,,
*French or Almond-leaved Willow	,, triandra	,,
*Common Osier	,, viminalis	,,
*Bedford Willow	,, viridis (many varieties and hybrids of above)	,,
*White Poplar or Abele	Populus alba	,,

Common Name.	Botanical Name.	Natural Order.
Grey Poplar	Populus canescens	Salicaceae
Black ,,	,, nigra	,,
Aspen or Trembling Poplar	,, tremula	,,
Butcher's Broom	Ruscus aculeatus	Liliaceae
Silver Fir	Abies nobilis	Coniferae
,,	,, pectinata	,,
Chili Pine or Monkey Puzzle-tree	Araucaria imbricata	,,
Atlas Cedar	Cedrus atlantica	,,
Deodar	,, Deodara	,,
Cedar of Lebanon	,, Libani	,,
Lawson's Cypress	Cupressus lawsoniana	,,
Monterey ,,	,, macrocarpa	,,
Yellow ,,	,, nootkatensis	,,
Maidenhair-tree	Ginkgo biloba (Salisburia adiantifolia)	,,
Common Juniper	Juniperus communis	,,
Savin	,, Sabina	,,
Common Larch	Larix europaea	,,
Japanese ,,	,, leptolepis	,,
White Spruce Fir	Picea alba	,,
Common Spruce	,, excelsa	,,
Black ,,	,, nigra	,,
Stone Pine	Pinus Cembra	,,
Corsican Pine	,, Laricio	,,
Austrian ,,	,, ,, var. nigricans (austriaca)	,,
True Pitch ,,	,, palustris	,,
Cluster ,,	,, Pinaster	,,
Stone or Umbrella Pine	,, Pinea	,,
Weymouth Pine	,, Strobus	,,
Scots Pine or Scotch Fir	,, sylvestris	,,
Douglas Fir	Pseudotsuga Douglasii	,,
Common Yew	Taxus baccata	,,
Irish ,,	,, ,, var. fastigiata	,,
Japanese Arborvitae	Thuya japonica	,,
American ,,	,, occidentalis	,,

NOTES ON METEOROLOGY.

The importance of the bearing of meteorology upon both horticultural and agricultural pursuits is daily becoming more widely recognised. In many of our large public parks thermometer screens have been erected, numerous private gardens keep a record of the rainfall and temperature, and, in addition, many persons display a practical interest in the subject.

When we consider how the farmer or gardener is more or less at the mercy of the unreliable weather experienced in these islands —his profits (if any) varying according to the favourableness or otherwise of the seasons—the necessity for a considerable enhancement of our knowledge of this subject will be readily apparent. To take but one instance in this connection, namely, the liability of the blossoms of fruit trees to damage by spring frosts—thus often rendering the crop a negligible one—if the grower had due warning of the likelihood of such a frost occurring, he could adopt some preventive measure in order to escape injury.

During recent years our knowledge of the various phenomena influencing the weather has greatly increased, and in consequence much more reliable forecasts are now issued by the Meteorological Office. In this respect, however, although the weather for the ensuing twenty-four hours can now be foretold with fair accuracy, it is still difficult to furnish reliable information covering a longer period.

Barometer.—The pressure of the atmosphere is indicated by the barometer, one of our most valuable guides in forecasting the weather. The atmospheric pressure is greatest at sea-level, the air becoming less dense as we ascend, and this natural law is used as a means of measuring the altitudes of mountains. Based on a knowledge of the various barometric readings over a large area, the direction and approximate strength of the wind can be estimated. Where the pressure varies greatly in different areas not very far distant from one another high winds will result, as the high pressure air, following the path of least resistance, will rush into the low pressure area in order to restore the equilibrium. Two kinds of barometers are used, viz., the aneroid, which is purely mechanical in its action, and the mercurial barometer.

The former is more sensitive, but the latter is the more accurate instrument.

A barometer should be fixed in an absolutely vertical position in a room or shed not subject to any decided fluctuation of temperature.

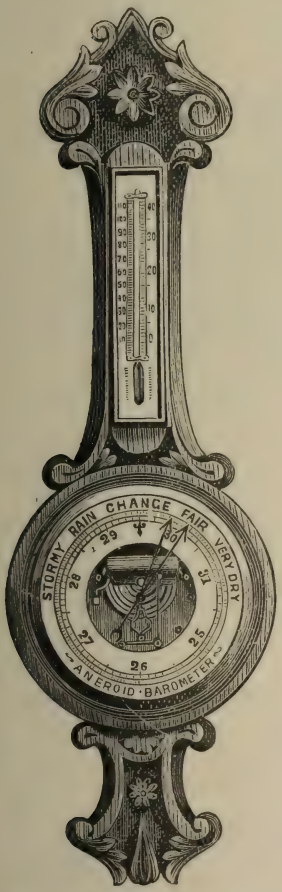

Fig. 1.—**Aneroid Barometer.**

Fig. 2.—**The New "Student's Standard Barometer."**

Thermometer Screen.—The different atmospheric temperatures are measured by various instruments, and, whenever possible, it is desirable that certain of these, such as the maximum, minimum, and wet and dry bulbs, should be enclosed in a properly constructed screen. For this purpose the Stevenson screen (fig. 3) is the most suitable, but space does not permit of a detailed description of its construction. In this type of screen the thermometers are suspended at a height of four feet above the ground.

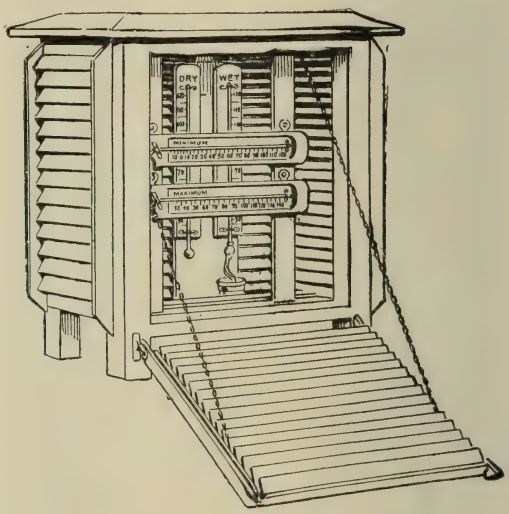

Fig. 3.—**Thermometer Screen.**
Stevenson's.

It is highly essential that the screen should occupy an open position where it will not be near tall objects of any description, but in any case the distance between the screen and any such object should be at least twice the height of the latter. The opening of the screen should face towards the north, so that the sun's rays may not fall on the instruments while observations are being taken.

Where a screen is not available the maximum and minimum thermometers may be hung on a post facing north, and protected from direct sunshine, so that they will register the temperature in the shade.

Maximum Thermometer.—The form most commonly used is a mercurial thermometer the tube of which is much constricted at the bend just above the bulb. When the temperature rises the mercury as it expands is forced past this constriction, but a subsequent fall of temperature and contraction of the mercury in the bulb causes the column to break at the constriction, leaving the upper end to register the highest shade temperature attained.

The thermometer, which should be hung horizontally, can be re-set by holding it bulb downwards and giving two or three sharp swings.

When the readings are taken at 9 a.m. every day the maximum temperature is always entered to the previous day, because, as a rule, the temperature recorded will have occurred the previous day.

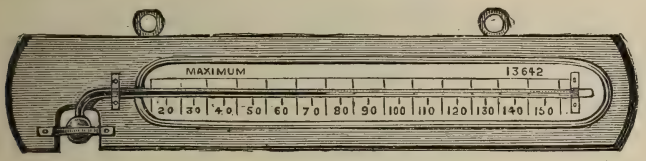

Fig. 4.—**Maximum Thermometer.**

Minimum Thermometer.—Differs from the maximum in being a spirit thermometer with a small index in the stem, but like the maximum it is hung in a horizontal position. When the temperature falls the index is carried towards the bulb by the spirit, but with a subsequent rise of temperature the spirit as it expands flows past the index, leaving it at the lowest temperature attained. The end of the index farthest from the bulb records the minimum temperature.

This thermometer is re-set by holding it vertically with the bulb upwards; the index will then slowly fall until it reaches the end of the column of spirit.

Fig. 5.—**Minimum Thermometer.**

If read at 9 a.m. the minimum temperature is entered to the same day.

Where a hygrometer is not used the present temperature can always be ascertained from the minimum thermometer when the readings are being taken. When the former is used, however, the temperature at the time of taking the observations is always entered from the dry bulb thermometer.

A thermometer recording both the maximum and minimum temperatures can be purchased when it is found desirable not to have two separate instruments.

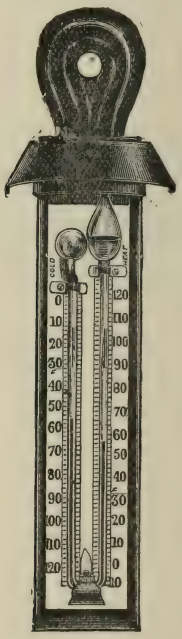

Fig. 6.—**Thermometer,** Six's, maximum and minimum.

Hygrometer.—This is used for determining the amount of water vapour in the air, or, in other words, the humidity of the atmosphere. It consists of two thermometers mounted side by side in a screen, the bulb of one, called the dry bulb, being left uncovered like an ordinary thermometer. The bulb of the other

thermometer, known as the wet bulb, is covered with a single thickness of muslin, which is kept constantly moist by the aid of a few strands of worsted or cotton lamp-wick attached to it, and dipping into a small reservoir of water placed beneath. Unless the atmosphere is saturated there will be a constant evaporation of moisture from the surface of the wet bulb, causing a loss of heat and consequent lowering of the temperature of this thermometer. The difference in the readings of the two thermometers will naturally vary according to the amount of water vapour in the air.

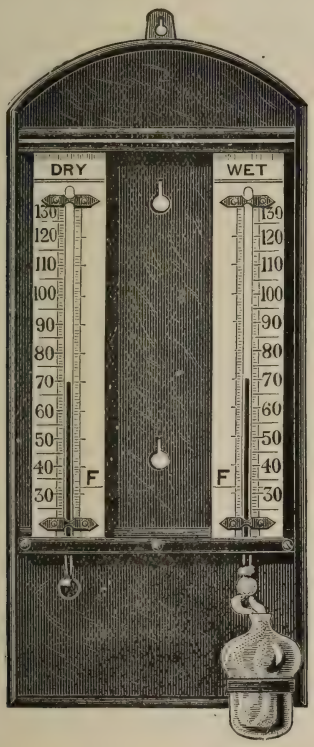

Fig. 7.—**Thermometer**, wet and dry bulb (Mason's hygrometer).

Terrestrial Radiation Thermometer.—Commonly known as a Grass minimum thermometer, this instrument is used for

estimating the effect of radiation from the earth's surface at night time. It is exposed freely on a grass surface, being supported on two Y-shaped pieces of wood at a height of one or two inches above the ground.

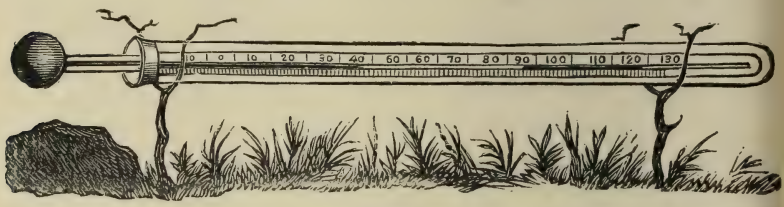

Fig. 8.—**Thermometer,** terrestrial, registering minimum.

Solar Radiation Thermometer.—This is used for recording the intensity of the sun's radiation, and consists of a maximum thermometer having the bulb and one inch of the stem coated with dull lamp-black. The whole is enclosed in a glass jacket which is exhausted of air.

Earth Thermometers.—The temperature of the ground is measured by means of thermometers suspended in iron tubes sunk into the earth to the required depth. One foot and four feet are the depths most commonly adopted.

Rain Gauge.—The best form of gauge for measuring the rainfall is known as the Snowdon pattern. This gauge is made of copper on account of its durability, the diameter of the funnel usually being eight inches, and is sunk in the ground at a depth which will allow the rim of the funnel to project one foot above the surface. The rim of the funnel is made of a stout ring of brass to prevent deformation, as if it were not a true circle the proper amount of rain would not be caught by the gauge. The sloping sides of the funnel are six inches below the rim in order to catch snow.

If possible a rain gauge should be placed in an open situation away from trees and buildings, but in any case the distance between the gauge and the nearest tall object should be at least twice the height of that object.

The rainfall is measured by pouring the water collected in the container into a special measuring glass. This glass will hold

half an inch of rain and is graduated in tenths and hundredths of an inch. The rainfall should be measured at 9 a.m. and entered to the previous day.

In the case of snow it can be measured in two or three ways, but of course is always measured or estimated as rain. If snow is not falling when the observations are being made the gauge (funnel and receiver) may be taken indoors and the snow melted and measured in the usual manner. On the other hand if it is snowing at the time a definite quantity of hot water may be poured into the gauge, and then the whole measured, the quantity of hot water used being afterwards deducted from the total amount. If the fall of snow is such as to be beyond the capacity of the funnel the depth can be measured fairly accurately with the aid of a ruler held vertically in the snow — a foot of snow being equal to an inch of rain. When snow is measured in this manner care should be taken to ascertain the depth on level ground where no snow has drifted.

An inch of rain is equivalent to 100 tons to the acre.

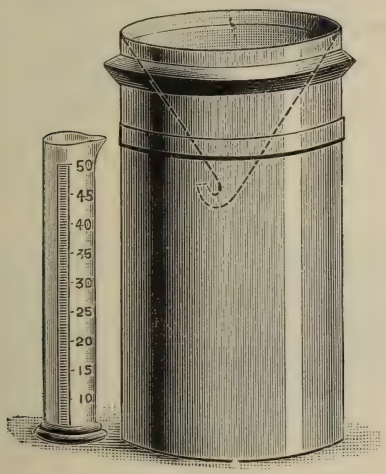

Fig. 9.—**Rain Gauge**, Glaisher's, diameter of gauge 8 inches, graduated jar, graduated to 100ths of an inch.

Sunshine Recorder.—By means of this instrument the number of hours of bright sunshine each day is recorded.

Known as the Campbell-Stokes Sunshine Recorder (fig. 10), it consists of a solid glass sphere, 4 inches in diameter, which brings the sun's rays to a focus on a card fitted in the form of a belt, approximately spherical, in a metal bowl. The card is marked off in hours and half-hours and the scorched line burned on the card by the sun's rays is measured in order to obtain the duration of bright sunshine for the day. A fresh card is inserted daily at any time between sunset and sunrise, and three different types of card are used during the year.

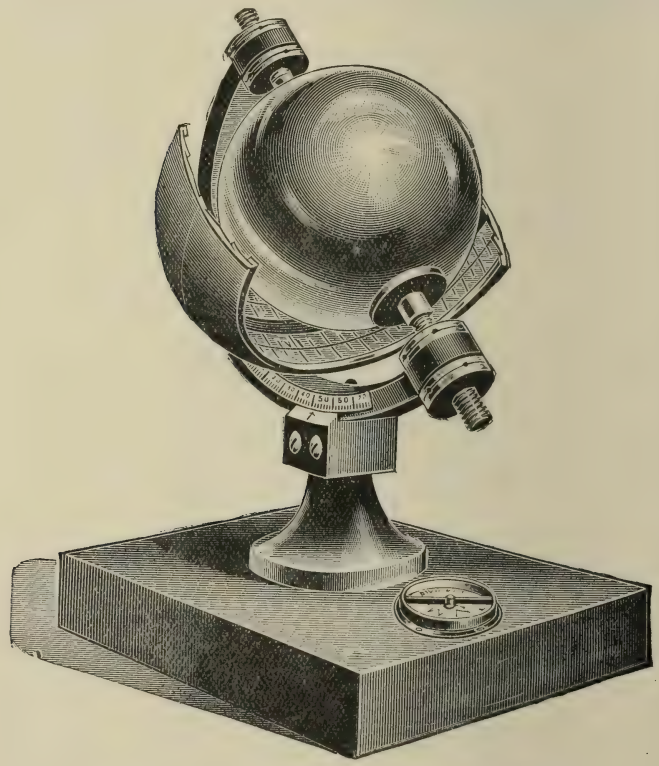

Fig. 10.—**Sunshine Recorder,** Campbell-Stokes.

Unfortunately this is an expensive instrument, its prohibitive cost (about £11) preventing its adoption in the majority of cases.

Wind.—When the daily observations are being made, the direction and force of the wind should be noted. The Beaufort Scale, as shown in the following table, is used for expressing the force of the wind.

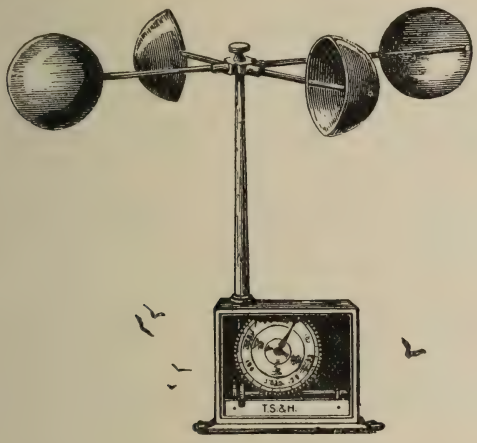

Fig. 11.—**Anemometer**, Robinson's pattern.

The Anemometer (fig. 11) is an instrument used for recording the daily velocity of the wind.

BEAUFORT SCALE.

Beaufort Number.	General Description.	Specification (for use on land).	Hourly velocity (miles).
0	Calm	Calm : smoke rises vertically	0
1	Light air	Direction of wind shown by smoke drift, but not by wind vanes	2
2	Slight breeze	Wind felt on face ; leaves rustle ; ordinary vane moved by wind	5
3	Gentle breeze	Leaves and small twigs in constant motion ; wind extends light flag	10
4	Moderate breeze	Raises dust and loose paper ; small branches are moved	15
5	Fresh breeze	Small trees in leaf begin to sway ; wavelets form on inland waters	21
6	Strong breeze	Large branches in motion ; whistling heard in telegraph wires ; umbrellas used with difficulty	27
7	High wind	Whole trees in motion ; inconvenience felt when walking against wind	35
8	Gale	Breaks twigs off trees ; generally impedes progress	42
9	Strong gale	Slight structural damage occurs (chimney pots and slates removed)	50
10	Whole gale	Seldom experienced inland ; trees uprooted ; considerable structural damage occurs	59
11	Storm	Very rarely experienced ; accompanied by widespread damage	68
12	Hurricane		above 75

Clouds.—The principal cloud forms are as follows :—

1 *Cirrus* (*Ci.*).—These are known as "mares' tails" and are the most lofty of the clouds. When at a slightly lower altitude they assume the less common form known as the "mackerel sky," an indication of fine weather.

2. *Cumulus* (*Cu.*).—These clouds are usually from two to four miles above the earth, and are often known as the "wool-pack" or "cauliflower cloud." They occur in the form of rounded masses and are very common in the summer-time.

3. *Stratus* (*S.*).—A layer of cloud of uniform thickness, sometimes at an elevation of much less than a mile.

4. *Nimbus* (*N.*).—A thick layer of dark clouds, without shape or form, and with ragged edges from which continued rain or snow is falling.

The proportion of the sky covered by cloud may be indicated on a numerical scale running from 0, cloudless, to 10, completely overcast.

WEEKLY WEATHER REPORT.

The following example of a week's weather, abstracted from the meteorological register of the College Station at Kilmarnock, will furnish a guide as to the manner in which the daily observations should be tabulated :—

Date.	Barometer.	Hygrometer.		Maximum.	Minimum.	Rain.	Bright Sunshine.	Wind.		Clouds.	
		Dry Bulb.	Wet Bulb.					Direction.	Force.	Amount.	Form.
1883.						Inches	H. M.				
May 2	29·46	43·7	41·9	50·0	39·7	·29	5 12	S.W.	6	10	S.
„ 3	29·41	43·1	41·7	47·6	39·8	·05	2 54	W.	2	10	S.
„ 4	29·29	45·2	43·7	51·5	39·8	·02	—	S.W.	7	10	S.
„ 5	29·53	41·5	38·7	48·5	37·6	—	5 6	S.W.	7	1	Cu.
„ 6	29·54	41·5	38·5	47·5	39·5	·38	3 42	S.W.	6	3	Cu.
„ 7	29·45	41·1	38·7	43·7	34·9	·20	1 12	W.	6	4	Cu.
„ 8	29·92	35·3	34·8	45·0	31·7	·27	6 6	W.	1	8	Cu.

ULLETIN No. 62.

The West of Scotland Agricultural College.

MANURES:

A Few Notes on their Composition, Unit System of Valuation, Mixing, &c.,

AND

PRICES PER UNIT AND PER TON,

ON

MARCH 15th, 1913,

BY

PROFESSOR R. A. BERRY.

GLASGOW, 1913.

MANURES.

Composition and Retail Cash Price per Ton for Two-Ton Lots, Free on Rail, Glasgow, on 15th March, 1913.

Supplying **Nitrogen** only.	**Nitrogen**, Per Cent.	Price Per Unit.	Price Per Ton.
Sulphate of Ammonia, -	20	14/1	£14 2 6
*Nitrate of Soda, 96 °/₀, -	15·5	15/7	12 2 6
Nitrate of Lime, - -	13	15/4	10 0 0
Nitrolim, Lime Nitrogen, -	18	11/10	10 12 6

Supplying **Potash** only.	**Potash**, Per Cent.		
Muriate of Potash, 80 °/₀, -	50	3/7	9 0 0
Sulphate of Potash, 90 °/₀,	48·7	4/4	10 10 0
Potash Manure Salts, -	30	3/3	4 17 6
Kainit, - - - - -	12·4	3/11	2 8 9

Supplying **Phosphate** only	Phosphate.		Phosphate.		
	Soluble Per Cent.	Total Per Cent.	Soluble.	Total.	
†Superphosphate of Lime,	26		2/		2 11 0
	30		1/10		2 16 0
	35		1/9½		3 3 0
	38		1/9½		3 9 0
‡Basic Slag, - -	22	28	1/7	1/3	1 15 0
	24	30	1/8	1/4	2 0 0
	30	35	1/6	1/3	2 5 0
	34	40	1/6	1/3	2 12 0
Mineral Phosphate, Ground,		60		/9½	2 7 6

	Composition Per Cent.				Price Per Unit.				
	Nitrogen.	Phosphate.		Potash.	§ Nitrogen.	Phosphate.		Potash.	
		Soluble.	Insoluble.			Soluble	Insoluble.		
Bone Meal,	3·7		52		16/9		1/6		£7 0 0
Steamed Bone Flour,	0·8		60		15/7		1/6		5 2 6
Dissolved Bones,	2·6	17	18		20/4	2/6	1/6		6 2 6
Guano,	1·61		36	2·3	23/		1/6	3/11	5 0 0
Fish Guano,	6·2		10		16/6		1/6		5 17 6
Dried Blood,	14				17/2				12 0 0

* Nitrate of Soda, 96 per cent. purity means that only 4 per cent. of other substances are present.
† In Superphosphate, soluble Phosphate means Phosphate soluble in water.
‡ In Basic Slag, soluble Phosphate means Phosphate soluble in a 2 per cent. solution of citric acid.
§ These unit prices give no indication of the relative manurial value of the nitrogen in the respective manures.

The market value of the insoluble Phosphate in Bone Manures and Guanos is taken at 1/6 per unit, as in Basic Slag, and the Nitrogen obtained as follows:—
e.g.—Bone Meal containing 52 per cent. Phosphates at 1/6 per unit=£3 18 0
now £7 0 0 – £3 18 0 = £3 2 0 ÷ 3·7 units = 16/9 per unit of Nitrogen.
The market value of the Soluble Phosphate in Dissolved Bones is taken at 2/6 per unit.

UNIT VALUATION.

The unit method of valuation is the only true basis of comparison of the price of the fertilising ingredients in different manures, but it must not be taken as a guide to their relative manurial values. *The prices fluctuate according to market conditions.*

A unit of either *nitrogen*, *phosphates*, or *potash* is one per cent. per ton, therefore nitrate of soda, containing 15·5 per cent. of nitrogen, contains 15·5 units of nitrogen per ton; to find the price per unit divide the price per ton of the manure by the percentage of the particular manurial ingredient.

The unit of nitrogen in nitrolim costs 11s. 10d.; to buy nitrogen in nitrate of soda at the same price per unit as in nitrolim the nitrate would cost 11s. 10d. × 15·5 = £9 3s. 5d. per ton instead of £12 2s. 6d. See opposite page.

In valuing *basic slag*, besides considering the unit prices of the phosphates soluble in a 2 per cent. solution of citric acid and of the total phosphates, it is important that the fineness of the grinding be such that at least 80 per cent. of the slag passes through a wire sieve with 9,600 meshes to the square inch, and a guarantee to this effect should be obtained. See opposite page for prices of the different grades.

In *bone meal, steamed bone flour, dissolved bones and guano*, the prices per unit of the phosphates and of the nitrogen are not the same as in manures containing one manurial ingredient only. Compare unit values on opposite page. Also calculate prices per ton on basis of soluble phosphates, 2s. 6d.; insoluble phosphates, 1s. 6d.; nitrogen, 14s. 6d.; potash, 3s. 11d per unit, and compare.

The Fertilisers and Feeding Stuffs Act, 1906, states **that in an invoice the actual percentages of nitrogen, soluble and insoluble phosphates, and of the potash in any manure must be stated as such,** hence the importance of the unit method of valuation.

SPECIAL, COMPOUNDED, OR MIXED MANURES.

As it is not customary for the merchant to publish in his catalogue the components of his compound manures, it is advisable to point out that these manures **should not contain mineral phosphate as the source of insoluble phosphate or shoddy, leather waste, hair, &c., as the source of the organic nitrogen.** Both the phosphates and the nitrogen from these sources are very inferior for manurial purposes.

A *special* manure, composed of superphosphate, sulphate of ammonia, and kainit, should be valued at the same rate as the prices per unit in the three manures mentioned, *e.g.* :—

Phosphate soluble, 20·0 °/₀, at 2s. 0d. per unit,	£2	0	0
Nitrogen, - - 3·3 °/₀, at 14s. 1d. „	2	6	6
Potash, - - 8·0 °/₀, at 3s. 11d. „	1	11	4
Price per ton, -	£5	17	10

10s. per ton should be added for cost of mixing, bags, &c.

If the special manure contains bones or guano as the source of its manurial ingredients, it should be valued according to the particular unit prices in these manures.

When the amount of insoluble phosphate present is about 2 per cent. and that of the soluble much larger, and their source is from a superphosphate, then the insoluble phosphate, need not be valued.

MIXING OF MANURES.

Instead of buying compounded manures, it may be much cheaper for the farmer to buy the single manures and mix them himself. He can then adjust the components to suit his particular soil and crop.

A good cement or brick floor is necessary for the mixing. Any lumps in the manures must be broken up, and the manures mixed as thoroughly as possible so as to ensure uniform composition and texture. The best way to proceed is to make a heap with layers of the different manures. Pass the whole through a riddle, afterwards completely turn the heap at least twice.

When selecting the manures for the mixture, it is necessary to see that any manures whose constituents, when mixed, may give rise to chemical action, be not chosen, otherwise considerable losses and deterioration of the respective manures may take place.

Perhaps the most obvious precaution is, to see that *lime* manures are not mixed with manures containing *ammonium salts*, such as in sulphate of ammonia or *organic nitrogen*, such as in guano, dung, &c.

THE FOLLOWING MANURES MAY BE SAFELY MIXED.

Sulphate of ammonia, nitrate of soda, nitrate of lime, bone flour and *meal, potash manures, meat* and *fish guanos*, and *organic manures.*

Superphosphate of lime, *dissolved bones*, *dissolved guanos*, *sulphate of ammonia*, *sulphate of potash*.

Basic slag, *precipitated phosphates*, *nitrolim*, *bone* and *potash manures*.

Superphosphate and *basic slag* may be mixed if the mixture is used at once.

The addition of a drier, such as *bone flour* or *bone meal* at the rate of about 2 cwts. per ton, will prevent the mixture from being damp and sticky, and will leave it in a good condition for sowing.

THE FOLLOWING MANURES SHOULD NOT BE MIXED.

Lime manures, *basic slag*, *precipitated phosphate*, should not be mixed with manures containing *ammonium salts* or *organic nitrogen*, such as with *guano*, *dung*, &c., otherwise ammonia will be lost.

Nitrate of soda, *nitrate of lime*, should not be mixed with *superphosphate* unless a little *bone flour* is added, and the mixture sown at once.

It is not desirable to mix at one time more manure than is required for say one field, because if allowed to stand any time the mixture may deteriorate or set into hard lumps.

When applying manure to the land it is important to distribute and incorporate the manure with the soil as evenly as possible.

Suppose it is required to make a mixture of sulphate of ammonia, superphosphate, and muriate of potash so as to give approximately the following composition :—

Phosphate soluble, - -	20·0 °/₀,
Nitrogen, - - - -	3·3 °/₀,
Potash, - - - -	8·0 °/₀,

then—If the mixture is to contain 20 °/₀ soluble phosphate, and if superphosphate containing 30 °/₀ soluble phosphate is to be used, it follows that the superphosphate must form $\frac{20}{30}$ parts or $\frac{2}{3}$ of the mixture.

Similarly sulphate of ammonia, containing 20 °/₀ nitrogen, will form $\frac{3{\cdot}3}{20}$ parts or $\frac{1}{6}$ of the mixture, and muriate of potash, containing 48 °/₀ potash, will form $\frac{8}{48}$ parts or $\frac{1}{6}$ of the mixture.

Stated in another way, the components of the mixture will be in the rates of:—

Superphosphate,	- -	4 parts by weight.
Sulphate of ammonia,	-	1 part ,,
Muriate of potash,	- -	1 ,,

Again, if it is required to substitute nitrate of lime for nitrate of soda, and yet apply the same weight of nitrogen per acre in the nitrate of lime as is contained in 1 cwt. of nitrate of soda, calculate as follows:—

Nitrate of lime contains 13 °/₀ nitrogen. Nitrate of soda, 15·5 °/₀ nitrogen—

then $\frac{112 \times 15{\cdot}5}{13} = 133$ lbs. nitrate of lime, equivalent to 1 cwt. nitrate of soda.

USEFUL FACTORS, &c.

Occasionally in manure bills the nitrogen is expressed as so much percentage of ammonia, the potash as so much percentage of sulphate of potash, &c. Now, as 17 parts of ammonia contain only 14 parts of nitrogen, and 23 parts of sulphate of potash contain only 12·5 parts of potash, a manure whose analysis is stated in this way would appear to be much richer in potash and nitrogen than it actually is—*e.g.*—

As Catalogued.		As it should be.	
Ammonia, - -	3·5 °/₀	Nitrogen, - -	2·88 °/₀
Sulphate of potash,	7·5 °/₀	Potash, - -	4·07 °/₀
Soluble phosphate,	21·0 °/₀	Soluble phosphate,	21·0 °/₀
Insoluble ,,	4·0 °/₀	Insoluble ,,	4·0 °/₀

If stated as follows:—

Nitrogen, - - - -	2·88 °/₀
Equal to ammonia, - -	3·55 °/₀
Potash, - - - -	4·07 °/₀
Equal to sulphate of potash, -	7·50 °/₀

it is in order.

TABLE OF FACTORS.

Percentage of Pure		Multiplied by	Give corresponding Percentage of Pure	
Nitrogen, -	N, -	1·214	Ammonia,	NH_3
,, -	,, -	4·714	Sulphate of Ammonia,	$(NH_4)^2SO_4$
,, -	,, -	6·071	Nitrate of Soda,	$NaNO_3$
,, -	,, -	5·857	Nitrate of Lime,	$Ca(NO_3)^2$
,, -	,, -	2·857	Nitrolim,	$CaCN_2$
Potash, -	K_2O,	1·85	Sulphate of Potassium,	K_2SO_4
,, -	,,	1·585	Muriate of Potassium,	KCl
,, -	,,	7·4	Kainit.	
Phosphoric Acid,	P_2O_5,	2·183	Phosphate of Lime,	$Ca_3(PO_4)^2$
Lime, -	CaO,	1·786	Carbonate of Lime,	$CaCO_3$
Magnesia, -	MgO,	2·09	Carbonate of Magnesia,	$MgCO_3$

Examples of the use of the above factors—

1. To express 20 °/₀ nitrogen as ammonia—

   $20 \times 1{\cdot}214 = 24{\cdot}28$ °/₀ ammonia.

2. To express 14·0 °/₀ phosphoric acid as phosphate of lime—

   $14{\cdot}0 \times 2{\cdot}183 = 30{\cdot}56$ °/₀ phosphate of lime.

To convert percentage of phosphate of lime into percentage of phosphoric acid divide percentage of the phosphate by 2·183.

CHEMICAL SYMBOLS FOR MANURIAL UNITS.

Nitrogen, - -	N.
Potash, - - -	K_2O.
Phosphate of lime, -	$Ca_3(PO_4)^2$.
Phosphoric acid, - -	P_2O_5.

In dissolved phosphates, 30 per cent. soluble phosphate means the percentage of phosphate of lime rendered soluble by acid.

My indebtedness is due to Principal W. G. R. Paterson, at whose suggestion these notes were published, and who has made valuable suggestions on their arrangement and scope.

The West of Scotland Agricultural College.

REPORT

ON

THE WEATHER

AT KILMARNOCK

FOR THE YEARS 1911 and 1912,

BY

REGINALD A. BERRY, F.I.C.,

Professor of Agricultural Chemistry.

GLASGOW, 1913.

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REPORT ON THE WEATHER

FOR THE YEARS

1911 and 1912.

By Professor BERRY.

The data for this report are taken from the records kept at the College Experiment Station, Kilmarnock. The report comprises the two years 1911 and 1912. The equipment of the station remains the same as in former years, and includes the following instruments :—

Standard Maximum Thermometer.
Standard Minimum Thermometer.
Wet and Dry Bulb Thermometer.
8-inch Rain Gauge.
Campbell Stokes Sunshine Recorder.
Standard Fortin Barometer.

Observations are taken daily at 9 a.m. Detailed summaries are forwarded monthly to the Scottish Meteorological Society, Edinburgh, the Royal Meteorological Society, London, and

weekly summaries to the *Scottish Farmer*, for publication in their Journals. For the figures relating to the Glasgow weather, given in Tables I., pages 95 and 102, we are indebted to the kindness of Prof. Becker, The City Observatory, Glasgow.

Before remarking on the weather of the two years in question, I should like to draw attention to an interesting paper on "The Mean Annual Rainfall of Scotland, 1871-1910," by the Secretary of the Meteorological Society, Edinburgh, and published in the journal of that society for 1910. In this paper the distribution of the rainfall over Scotland is exhaustively dealt with. Using average figures obtained over a period of forty years it has been possible to divide the country into zones according to the mean annual rainfall. The different zones are shown on a map in different shades of blue. In the area under the College the mean annual rainfall seldom falls below 35 inches per annum, which is the average rainfall registered for the low-lying land bordering the Ayrshire coast and the south-west coast of Wigtonshire. In Ayrshire the coastal zone runs from a little north of Ardrossan, extending inland south of Kilmarnock to Mauchline, thence in a south-westerly direction to the coast a little south of Girvan. In Wigtonshire the coastal zone runs from Loch Ryan, extending inland to Glenluce, thence to the coast at Whithorn. In the south and south-western counties generally the annual rainfall lies between 40-50 inches, except on the higher and more exposed areas in the neighbourhood of Lochs Doon, Dee, and Trool, where it fluctuates between 50 and 80 inches per annum. In Argyllshire and the adjacent islands, the western portion of Renfrewshire, Dunbartonshire, and Stirlingshire the average rainfall lies between 60-80 inches, and not infrequently exceeds 100 inches per annum in the higher and more exposed areas. At the Ben Nevis Observatory a rainfall of 187 inches was recorded in 1899. In the central and eastern portions of these counties the rainfall lies between 40 and 60 inches per annum.

1911.

Table I., page 95, contains a summary of the weather records for this year taken at Kilmarnock and Glasgow respectively.

Table I.

Month.	Kilmarnock, 1911.					Glasgow, 1911.			
	Rainfall.	Rainy Days.	Mean Temperatures.	Sunshine.		Rainfall.	Rainy Days.	Mean Temperatures.	Sunshine.
	Inches.		F.°	H.	M.	Inches.		F.°	H.
January, -	2·89	17	39·85	41	54	2·16	17	40·8	21
February, -	6·18	20	39·2	44	30	6·10	18	39·9	41
March, -	1·41	13	40·4	133	42	1·21	15	40·5	87
April, - -	2·68	15	44·2	91	0	2·85	15	45·0	93
May, - -	2·35	14	52·95	213	48	1·98	15	53·2	203
June, - -	2·09	13	55·25	216	6	2·22	12	56·1	199
July, - -	2·47	18	59·6	189	36	2·18	18	59·8	179
August, -	2·53	14	60·4	216	6	2·13	14	60·0	170
September, -	2·02	15	52·8	128	12	1·75	13	53·1	115
October, -	2·69	11	45·4	83	48	3·23	13	46·4	59
November, -	4·08	17	40·4	56	24	5·00	21	41·9	35
December, -	4·62	29	42·2	28	42	5·45	28	42·6	13
Whole Year,	36·01	196	47·72	1,443	48	36·26	199	48·3	1,215
Average, -	40·08	205	46·8	1,188	28	38·41	212	46·9	1,108

At both centres the annual rainfall, mean temperature, and hours of bright sunshine were considerably above the average. At Kilmarnock the number of rainy days and the mean temperature was a little below and the hours of bright sunshine a little above that of Glasgow.

In the following tables more detailed information of the Records kept at Kilmarnock is given.

TABLE II.

MONTH.	RAINFALL (INCHES.)							* RAINY DAYS.	
	1906.	1907.	1908.	1909.	1910.	1911.	Difference of 1911 from Average of 1901-1911.	1911.	Difference of 1911 from Average of 1901-1911.
Jan., -	3·47	2·12	5·15	4·72	3·25	2·89	−1·03	17	−2
Feb., -	2·67	2·89	2·93	3·22	4·85	6·18	+2·87	20	+3
Mar., -	2·72	3·92	4·06	1·62	1·69	1·41	−1·77	13	−5
April, -	1·35	2·71	1·97	4·05	2·89	2·68	+0·06	15	−1
May, -	4·52	3·34	2·62	2·39	2·11	2·35	−0·34	14	−3
June, -	1·06	3·00	2·62	3·07	1·45	2·09	−0·02	13	0
July, -	2·85	2·35	2·81	4·76	3·23	2·47	−0·64	18	+1
Aug., -	4·91	4·05	4·00	3·49	7·19	2·53	−2·14	14	−5
Sept., -	1·70	1·26	5·09	2·12	2·07	2·02	−0·94	15	0
Oct., -	5·57	6·17	0·97	4·69	2·37	2·69	−1·28	11	−6
Nov., -	3·66	3·66	3·52	2·55	3·31	4·08	+0·65	17	0
Dec., -	4·53	4·88	3·86	4·23	3·54	4·62	+0·51	29	+9
Whole Year,	39·01	40·35	39·60	40·91	37·95	36·01	−4·07	196	−9

\+ indicates above and − below the average.
1 inch Rainfall = 100 tons water per acre.
* ·01 inches Rainfall constitutes a rainy day.

Table II., page 96, gives the monthly rainfall in inches for the present and preceding five years, also the number of rainy days in 1911.

With the exception of 1902, when 31·11 inches of rain were recorded, the total rainfall for this year was the lowest since records were commenced at Kilmarnock in 1901. There was a deficiency of 4·06 inches of rain from the average and of 1·94 inches from the previous year.

The rainfall over the year was most unequally distributed. The first three months were alternately dry, wet, and dry. January was 1·03 inches below, February 2·87 inches above, and March 1·77 inches below, the average. April was about normal, then followed one of the most remarkable series of dry months experienced in the West of Scotland, extending from May to October. Each month registered a deficiency of rain from the average. November and December were wetter than usual, but by no means made up for the deficiency of rain for the year.

The wettest month of the year was February with 6·18 inches of rain, an increase of 2·87 inches from the average and 23 wet days. The driest month was fortunately March with 1·41 inches of rain, a decrease of 1·77 inches from the average and 13 wet days. The rainfall in both of these months constitute a record at the experiment station. The rainfall for August was also the lowest registered for that month since 1901. The heaviest fall of rain within 24 hours was on the 29th October, when 1·36 inches were recorded.

There were several long spells of dry weather from March 12 to April 14th, only ·11 inch of rain fell, from May 24th to June 15th only ·11 inch was recorded, from August 6th to 22nd ·16 inch, and from September 30th to October 18th only ·07 inch was registered.

The spring of this year was very favourable for farming operations, the exceptionally dry weather of March soon improved the sodden condition of the land from the heavy rain of the previous month. There was a good seed bed, and the showery month of April helped to complete one of the finest springs on record. The droughty conditions experienced in the latter half of May until the middle of June checked growth rather seriously, especially on the lighter soils. Splendid weather was experienced both for the hay and corn harvest. The crops were light on the sandy and gravelly soils, but they were about normal on the heavier land.

Table III., page 98, gives the rainfall for each quarter since 1906, and the difference of 1911 from the average 1901-1911.

TABLE III.

MONTH.	RAINFALL (Inches).						Difference of 1911 from Average of 1901-1911.	Average quarterly rainfall expressed as percentage of whole year, using average of 1901-1911.
	1906.	1907.	1908.	1909.	1910.	1911.		
Jan.-Mar.,	8·86	8·93	12·14	9·56	9·79	10·48	+0·07	25·9
April-June,	6·93	9·05	7·21	9·51	6·45	7·12	−0·29	18·5
July-Sept.,	9·46	7·66	11·90	10·37	12·49	7·02	−3·73	26·9
Oct.-Dec.,	13·76	14·71	8·35	11·47	9·22	11·39	−0·12	28·7
Whole Year,	39·01	40·35	39·60	40·91	37·95	36·01	−4·07	

Table IV., page 98, gives the bright sunshine, mean temperature, and greatest range of temperature of each month for the year 1911.

TABLE IV.

MONTH.	Hours of Bright Sunshine.				Mean Temperature. F.°		Highest Maximum Temperature F.°, 1911.	Lowest Minimum Temperature F.°, 1911.	Greatest Range of Temperature F.°, 1911.
	1911.		Difference of 1911 from Average of 1902-1911.		1911.	Difference of 1911 from Average of 1902-1911.			
	H.	M.	H.	M.					
January,	41	54	+11	11	39·8	+0·88	51	22	29
February,	44	30	− 9	37	39·2	+0·85	56	19	37
March,	133	42	+43	14	40·4	−0·27	51	24	27
April,	91	0	−27	48	44·2	+0·67	60	20	40
May,	213	48	+50	9	52·9	+3·26	79	33	46
June,	216	6	+39	20	55·2	+0·89	78	31	47
July,	189	36	+28	9	59·6	+2·25	81	38	43
August,	216	6	+73	4	60·4	+3·81	82	41	41
September,	128	12	+19	37	52·8	−0·45	69	32	37
October,	83	48	+11	42	45·4	−2·54	61	21	40
November,	56	24	+12	52	40·4	−0·87	55	22	33
December,	28	42	+ 3	29	42·2	+2·38	53	28	25

With the exception of March, the mean temperature for the first four months was a little above the average. Easterly wind and cold frosty weather prevailed in March. The spring and summer months were the warmest and the sunniest on record at the experiment station. The mean temperature for August was 3·81° F. above the average for the month. The highest temperature in the shade reached during the year was 82° F. registered on the 18th August—the lowest was on February 2nd, when the thermometer fell to 19° F. The month of February registered the lowest mean temperature, namely, 39·2° F., and the month of August with a mean temperature of 60·4° F. was the highest for the year. The greatest monthly range of temperature occurred in June, when there was a difference of 47° F. between the highest and lowest readings. The smallest was for December, namely, a difference of 25° F. between the highest and lowest readings.

The hours of bright sunshine for 1911 was generally above the average for most months of the year. An increase of 70 hours above the average was recorded for the month of August.

Table V., page 99, gives the days on which frost occurred. The last spring frost was recorded on April 10th, and the first frost in the autumn on 16th September.

Table V.

Month.	Occurrence of Frost, 1911.
January, - -	2nd, 4th, 6th, 7th, 12th, 13th, 14th, 21st, 31st.
February, -	1st, 2nd, 3rd, 4th, 5th, 6th, 11th, 12th, 27th.
March, - -	5th, 7th, 8th, 13th, 14th, 16th, 22nd, 24th, 26th, 27th.
April, - -	2nd, 3rd, 4th, 5th, 6th, 9th, 10th.
June, - -	14th.
September, -	16th.
October, - -	1st, 10th, 11th, 25th, 26th, 28th, 29th.
November, -	9th, 10th, 11th, 12th, 19th, 20th, 21st, 22nd, 23rd, 24th, 25th, 26th.
December, -	4th, 9th, 23rd, 25th.

The late spring was comparatively free from frost. The short sharp spell early in April did some injury. Sharp frosts occurred in October and November. 11° were registered on the 28th October and 12° on the 10th of November. Only four frosts were registered in December.

REMARKS ON THE WEATHER OF EACH MONTH.

January opened with dry, frosty weather, which continued until the 13th. A short break of stormy weather intervened on the 6th and 7th. The remainder of the month was open and mild. *February*—The first week was frosty; thereafter and until the end of the month the weather was very wet and unsettled. It was the wettest month of the year, and included 23 rainy days. Prevailing winds—south-west. *March* opened wet and stormy; a change set in on the 4th; then followed a remarkable spell of dry weather which continued until the end of the month. Frequent slight frosts occurred, but with the cold easterly winds and bright sunshine, the soil dried quickly, and much seed was sown under very favourable conditions. It was the driest month of the year. Prevailing winds—north-east. *April*—The fine dry weather of the previous month continued well into April. The latter half of the month was showery, rain being registered on most days. *May* was a warm, sunny, and relatively dry month, and vegetation made great progress. The mean temprature was 3·6° F. above the average for the month. *June*—The genial weather of the previous month continued through the greater part of June. The effect of the continued droughty weather was, however, evident at this date, especially on the lighter soils. Showery weather occurred in the middle of the month which did much good. *July* opened with cooler weather, but the second and third weeks were hot and dry, and hay was cut and gathered in excellent condition. 19 dry days were registered. *August* was one of the driest on record. The rainfall was 2·14 inches below the average and the mean

temperature 3·8° F. above. The 18th was the hottest day of the year. 82° F. was registered in the shade. Corn ripened rapidly, and the harvest was secured in almost ideal conditions. *September*—The first three weeks were dry and warm; colder and stormy weather then set in. A slight frost was registered on the 16th. *October* opened with fine, dry weather, which continued until the middle of the month. Frosts occurred on the 10th and 11th, and again on the 25th to the end of the month. Potatoes were dug and secured in good weather, and much ploughing up of stubble was got through. The rainfall was 1·28 inches below the average. *November* was a variable month, with frosty and stormy weather alternating. The rainfall was ·65 inch above the average. *December* was exceedingly mild, only 4° frost was registered. The rainfall was a little above the average.

The year 1911 will be remembered for its exceptionally fine spring and summer, one of the driest and warmest on record. The crops were good except on the lighter soils, when the yield was below the average. Ideal conditions prevailed both at seeding and harvest.

1912.

Table 1 below contains a summary of the weather records for this year taken at Kilmarnock and Glasgow respectively.

Table I.

Month.	Kilmarnock, 1912.					Glasgow, 1912.			
	Rainfall.	Rainy Days.	Mean Temperatures.	Sunshine.		Rainfall.	Rainy Days.	Mean Temperatures.	Sunshine.
	Inches.		F.°	H.	M.	Inches.		F.°	H.
January, -	2·14	18	36·8	30	12	2·74	17	38·1	21
February, -	2·19	14	39·7	65	54	3·31	16	40·1	43
March, -	4·88	24	43·7	93	0	4·28	26	43·1	75
April, - -	1·98	7	47·4	189	48	1·35	9	47·5	157
May, - -	1·16	10	50·9	159	48	1·31	13	50·7	144
June, - -	3·58	20	55·5	122	54	4·86	24	54·3	73
July, - -	2·29	11	58·5	184	48	2·25	12	58·1	147
August, -	2·96	23	53·3	67	48	4·14	19	53·2	48
September, -	2·65	11	50·3	116	36	2·85	10	50·7	93
October, -	3·64	17	46·2	62	36	3·64	19	46·7	53
November, -	3·56	20	41·8	17	24	4·03	16	42·9	12
December, -	5·73	27	42·1	4	6	6·21	26	42·4	2
Whole Year,	36·76	202	51·47	1,114	54	40·97	207	47·3	868
Average, -	39·80	205	46·8	1,181	47	38·47	212	46·9	1,100

Comparing the annual rainfall at the two centres. Kilmarnock was much below and Glasgow much above the average, and there was a difference of 4·21 inches of rain between the two centres for the year. The rainfall registered in Glasgow for the months of January, February, June, November, and December was considerably higher than that of Kilmarnock. At both centres the mean temperature was above and the bright sunshine below the average.

In the following tables more detailed information of the records kept at Kilmarnock is given.

TABLE II.

Month.	Rainfall (Inches).							Rainy Days.	
	1907.	1908.	1909.	1910.	1911.	1912.	Difference of 1912 from Average of 1901-1912.	1912.	Difference of 1912 from Average of 1901-1912.
Jan., -	2·12	5·15	4·72	3·25	2·89	2·14	−1·62	18	−1
Feb., -	2·89	2·93	3·22	4·85	6·18	2·19	−1·03	14	−3
Mar., -	3·92	4·06	1·62	1·69	1·41	4·88	+1·56	24	+5
April, -	2·71	1·97	4·05	2·89	2·68	1·98	−0·59	7	−8
May, -	3·34	2·62	2·39	2·11	2·35	1·16	−1·40	10	−7
June, -	3·00	2·62	3·07	1·45	2·09	3·58	+1·35	20	+7
July, -	2·35	2·81	4·76	3·23	2·47	2·29	−0·76	11	−5
Aug., -	4·05	4·00	3·49	7·19	2·53	2·96	−1·56	23	+3
Sept. -	1·26	5·09	2·12	2·07	2·02	2·65	−0·29	11	−3
Oct., -	6·17	0·97	4·69	2·37	2·69	3·64	−0·30	17	0
Nov., -	3·66	3·52	2·55	3·31	4·08	3·56	+0·12	20	+3
Dec., -	4·88	3·86	4·23	3·54	4·62	5·73	+1·48	27	+6
Whole Year,	40·35	39·60	40·91	37·95	36·01	36·76	−3·04	202	−3

+ Indicates above and − below the average.
1 inch rainfall = 100 tons of water per acre.
·01 inches of rain constitutes a rainy day.

Table II., page 103, gives the monthly rainfall in inches for the present and five preceding years, also the number of rainy days per month for the year 1912.

The total rainfall for the year was 3·06 inches below the average, and only ·65 inches less than that of the previous year. The first two months were drier than usual, and were followed by a wet March with 24 rainy days and 1·56 inches of rain above the average. The unfavourable weather of this month considerably interfered with the working of the land, and seeding operations were in consequence delayed. Fortunately April was drier than usual, with only seven wet days and a total rainfall of only 1·98 inches. Arrears in sowing were soon made good, and under the favourable circumstances growth was rapid. May was a seasonable month, and was followed by a wet June, with 20 rainy days and a rainfall of 1·35 inches above the average. July in the first half was dry, but the weather broke down towards the end of the month. August was very showery, with 23 wet days. September was dry, and the harvest was got in in fair order. October and November were normal. December was a very wet month.

December, with 5·73 inches of rain, was the wettest, and May, with 1·16 inches, was the driest month of the year. The heaviest fall of rain within 24 hours was on April 4th, when 1·61 inches were recorded.

There was a long spell of dry weather in April, from the 10th-30th only ·07 inches of rain fell. Short dry spells occurred in January, July, and September.

Table III., page 104, gives the rainfall for each quarter for the present and preceding five years, and the difference of 1912 from the average of 1901-1912. The quarterly distribution of rain for this year was very similar to that of the preceding year.

TABLE III.

MONTHS.	RAINFALL (Inches).						Difference of 1912 from average of 1901-1912.	Average quarterly rainfall expressed as percentage of whole year, using average of 1901-1912.
	1907.	1908.	1909.	1910.	1911.	1912.		
Jan.-Mar.,	8·93	12·14	9·56	9·79	10·48	9·21	−1·09	25·9
April-June,	9·05	7·21	9·51	6·54	7·12	6·72	−0·64	18·5
July-Sept.,	7·66	11·90	10·37	12·49	7·02	7·90	−2·61	26·4
Oct.-Dec.,	14·71	8·35	11·47	9·22	11·39	12·93	+1·30	29·2
Whole Year,	40·35	39·60	40·91	37·95	36·01	36·76	−3·04	

\+ indicates above, and − below the average.

Table IV., page 105, gives the bright sunshine, mean temperature, and greatest range of temperature for each month for the year 1912.

TABLE IV.

MONTH.	Hours of Bright Sunshine.				Mean Temperature. F.°		Highest Maximum Temperature F.°, 1912.	Lowest Minimum Temperature F.°, 1912.	Greatest Range of Temperature, F.°, 1912.
	1912.		Difference of 1912 from Average of 1902-1912.		1912.	Difference of 1912 from Average of 1902-1912.			
	H.	M.	H.	M.					
January, - -	30	12	− 0	28	36·8	−2·0	53	19	34
February, - -	65	54	+10	42	39·7	+1·2	53	12	41
March, - -	93	0	+ 2	18	43·7	+2·6	54	30	24
April, - -	189	48	+64	32	47·4	+3·5	71	27	44
May, - -	159	48	− 3	54	50·9	+1·1	64	32	32
June, - -	122	54	−48	59	55·5	+1·0	68	37	31
July, - -	184	48	+21	13	58·5	+1·3	76	37	39
August, - -	67	48	−68	23	53·3	−3·0	68	34	34
September, -	116	36	+ 7	12	50·3	−2·7	66	29	37
October, - -	62	36	− 8	40	46·2	−1·6	61	22	39
November, -	17	24	−23	46	41·8	+0·5	56	6	50
December, -	4	6	−19	12	42·1	+2·1	54	11	43

The month of January, which registered 14 frosts, was unusually cold. On the whole the spring and early summer months were milder than usual, and there was an absence of late spring frosts. 1° frost was recorded on the 16th May. April, with its bright sunshine, had a mean temperature of 3·5° above the average. May though bright was cool owing to the prevailing easterly winds. June was cold and sunless. July was seasonable. August was dull and cold, with a mean temperature 3° below the average. Harvest under such conditions was late, but the fair weather of September ripened the corn and the crops were harvested in good condition. October and November were about normal. December was very mild and wet.

The month of January registered the lowest mean monthly temperature, namely, 36·8° F., and July, with 58·5° F., the highest for the year. The highest mean temperature in the shade for the year was 76° F., registered on the 15th July, and the lowest was on the 30th November when the thermometer fell to 6° F. The greatest monthly range of temperature occurred in November, when there was a difference of 50° F. between the highest and lowest reading. The smallest was in March, namely, a difference of 24° between the highest and lowest reading.

The bright sunshine for 1912 was about normal; the months of April and July were the sunniest. August had a deficiency of 68 hours from the average. December had the least sunshine for the year.

Table V.

Month.	Occurrence of Frost, 1912.
January, - -	7th, 8th, 18th, 19th, 20th, 23rd, 24th, 25th, 26th, 27th, 28th, 29th, 30th, 31st.
February, -	1st, 2nd, 3rd, 4th, 5th, 6th, 11th, 21st.
March, - -	16th, 23rd.
April, - -	1st, 10th, 12th, 28th.
May, - -	13th.
September, -	11th.
October, - -	2nd, 3rd, 4th, 21st, 22nd, 23rd.
November, -	1st, 2nd, 13th, 14th, 15th, 28th, 29th, 30th.
December, -	1st, 2nd, 3rd, 27th.

Table V., page 106, gives the days on which frost occurred. The last frost was on the 16th May, and the first in the autumn on the 11th September.

REMARKS ON THE WEATHER OF EACH MONTH.

January was dry and frosty with the exception of a short spell of unsettled weather in the middle of the month. Prevailing wind—north-east. *February* was frosty in the early part of the month, and very unsettled towards the end. It was, however, milder and drier than usual, a deficiency of 1·03 inches of rain from the average was recorded. *March* was exceptionally wet and mild, only two slight frosts were registered—the rainfall was 1·56 inches above and the mean temperature 2·6° below the average. It was a bad month for farming operations. *April* was one of the finest on record. It was the sunniest month of the year, a heavy storm occurred on the 4th, when the greater part of the rain for the month was recorded. The corn was sown under ideal conditions. *May* was exceptionally dry, and a deficiency of 1·4 inches of rain was recorded. It was suitable growing weather, except on the lighter soils when the droughty condition prevailing somewhat checked growth. *June* was unsettled and stormy, but after the dry weather experienced in the previous month the rain did good. *July* was a seasonable month, drier than usual, ideal weather prevailed for hay-making, and the hay crop was generally good. *August* was cold and changeable, though the rainfall was 1·57 inches below the average, rain was registered on 23 days. The ripening of corn made little progress. Prevailing wind—east. *September* opened with very changeable weather and a severe gale occurred on the 3rd, when 1 inch of rain was registered. Afterwards settled conditions prevailed and the harvest was got in excellent condition. *October*, the first fortnight was dry and frosty, afterwards the weather was unsettled. Frost occurred on the 21st and 23rd, the rainfall and mean temperature was a little below the average. *November* was a fine month with occasional frosts—on the 30th 26° of frost were registered. *December* was unusually mild and wet. The rainfall was 1·48 inches, and the mean temperature 2·1° F. above the average.

The outstanding features of this year were the wet month of March, the exceptionally dry April and May, excellent hay-making weather, and a late harvest gathered in good condition.

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The West of Scotland Agricultural College.

POULTRY KEEPING.

BY

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POULTRY KEEPING.

By Miss AGNES KINROSS, N.D.D., Instructress in Poultry Keeping and Manageress of Poultry Department, Holmes, Kilmarnock.

This Bulletin is intended to give information to farmers and others on matters pertaining to the keeping of poultry.

It is the object of the College to assist in every way the utility side of poultry keeping, by advice and demonstration to all those who are engaged in the production of eggs and table fowls, and also to guide the beginner, so that those who take up the industry may do so with a fair chance of success.

The point cannot be too strongly emphasised that poultry keeping as a sole means of livelihood needs capital, experience, skill, and a special adaptability for the work which few possess, as the personal element counts for much.

Poultry keeping in conjunction with some other branch of rural industry, such as fruit growing, bee keeping, &c., is likely to be more successful than alone. On the ordinary farm the women folk, and especially the daughters, would find an excellent means of augmenting the general income and, at the same time, an interesting and fascinating occupation; while on the croft or small holding poultry should form the chief source of the income of the crofter or small holder.

While egg production is in most cases the main item, the production of better table poultry is capable of much greater and profitable expansion, so that the poultry keeper should always try to have this point in view as well.

The aim of this Bulletin will be to give plain practical advice regarding the best methods. Correct ideas are essential. Practical experience must be acquired to ensure success. It is wrong to

start poultry keeping, either as an independent business or as a side-line, without some experience. Poultry keeping cannot be learned from text-books alone.

There are great possibilities of development in poultry keeping on the farm, and the time is now practically over when the hen was viewed as a necessary evil.

BREEDS OF POULTRY.

There is no necessity to discuss all breeds of poultry in this Bulletin, but only to give the characteristics of a few of the chief breeds for special purposes.

From a commercial standpoint the needs for egg production are :—

1. General Purpose Breeds.
2. Egg or Non-sitting Breeds.

For classification, the so-called "General Purpose" breeds are those that will produce a fair number of eggs in a season, tinted in shell; that will sit, hatch, and rear chickens. The surplus cockerels will make either very good spring chickens or plump roasting fowls, easily fattened. As one has generally to sell off surplus cockerels and hens, it is as well to give some consideration to the meat properties. These should include such breeds as Orpingtons, Wyandottes, Plymouth Rocks, Rhode Island Reds, and Faverolles. For exposed positions and damp heavy soils, Rhode Island Reds, White Wyandottes, Orpingtons, and Plymouth Rocks are recommended, especially Rhode Island Reds and White Wyandottes. Faverolles are better suited to lighter soils and more sheltered positions.

These "General Purpose" fowls are of fair size, heavily feathered, with medium-sized combs and wattles, and they endure cold weather because of these points.

Egg Breeds.

The egg breeds include the small or Mediterranean breeds, which are very active and quick to mature. They do not fatten well and, being small-bodied birds, are poor for table purposes.

They have large combs and wattles, which make them rather sensitive to low temperatures. They produce white-shelled eggs, are usually non-sitters, and of no use as mothers, even although an occasional fowl should become broody. Good representatives of this class are Black and White Leghorns. The Minorca and Andalusian are now of little use as good egg producers, being bred more for exhibition. They are large-sized and have big soft combs.

For very exposed positions and damp soils the Black Leghorn will do better than the white variety.

Egg Production.

In considering this subject there are several points worthy of notice, which will be dealt with separately, viz.:—

1. The breed and strain.
2. The housing and range.
3. The food used and the method of giving it.
4. Cleanliness and the attention given by the poultry keeper.

Selection of Breeds.

It is unsafe to recommend one particular breed, as experience shows that the strain is of much greater importance, but it may be safely stated that the "General Purpose" breeds usually lay better during the winter months, if they are hatched in time. than do the lighter breeds. The latter are more affected by climatic changes during winter, their egg production declining during a cold snap. We have our best egg production yearly from March and April hatched pullets. These commence to lay towards the beginning of October and November, if well reared. Earlier hatched pullets lay probably in August and September, have a moult, and cease laying for some considerable time. They are useful, however, for a supply of eggs at a time when the older hens are going into their moult in September and October, and before the later-hatched pullets commence laying. There is, therefore, no advantage in having very early hatched pullets, unless for the reason just stated.

Hens during their second season lay fairly well. They are also excellent as breeders. Fowls should not be kept for egg production beyond their second laying season. They should be sold off at about $2\frac{1}{2}$ years old, to make room for the pullets and to save congestion in the poultry yard, by having hens of so many different ages.

Improvement of existing Stock.

This can be done :—

1. By buying sittings of eggs from which good pullets and male birds may be obtained.

2. By the introduction of suitable pure-bred male birds from a reliable source.

Farmers are often unwilling to pay a reasonable price for good males. Much harm may be done by the introduction of unsuitable birds ; they should be selected from a reliable source.

3. By selection of the better fowls, instead of breeding from the poultry yard indiscriminately.

In breeding, the vitality and vigour of the stock should always be kept in view. This is of great importance for maintenance of good egg production.

For egg production select active, alert, vigorous birds, small or medium in size, of any particular breed. These are generally better layers than the larger or exhibition type.

The male bird should be chosen with as much care, as he has also the power of stamping good qualities upon the progeny, and he should, if possible, come from a well-known egg-producing strain. We are of opinion that the greatest good will result from the careful breeding of male birds from egg-producing mothers.

To maintain good egg production and greater vigour for several generations, fully-matured stock should be bred from, either on one side or the other, but preferably on the female side. The best results are got from second season's hens mated with an early-hatched, well-grown, vigorous male bird.

In mating-up a breeding pen, the number of birds will depend largely upon the vigour of the male. Our experience has been

See page 113.

VIEW OF THE POULTRY FARM, KILMARNOCK.

See page 117.

WHITE WYANDOTTES.

SALMON FAVEROLLES.

See page 118.

RHODE ISLAND REDS.

BUFF ORPINGTONS.

BARRED PLYMOUTH ROCKS.

See page 119.

that, with a young vigorous male and a good run, 15-20 hens may form the pen. In smaller confined runs, 8-12 may prove sufficient. As much harm may occasionally occur from too few birds as from too many, the mating-up of pens must therefore be left to the experience and discretion of the poultry keeper.

The stock should possess straight breast-bones. A deformed or crooked-breasted bird should not be bred from.

Coloured leg-bands should be used for marking the birds, so that they may be systematically sold out each year.

SHORT DESCRIPTIONS OF THE BREEDS KEPT AT HOLMES FARM.

General Purposes Breeds.

1. – *White Wyandotte.*

These are blocky birds, medium in size, rather short on leg, flesh and legs yellow, rose comb.

These have been found to be hardy, an excellent all-round farm fowl, and give good returns for the food consumed.

They are given to broodiness in late spring and summer. The cockerels make excellent spring chickens at 2½-3 months old, and later very good roasting chickens, carrying a large amount of breast meat of good quality.

The average production from 1st October, 1912, to 31st September, 1913, of 18 pullets was 173·8 eggs per bird, 1 pullet laying 214 eggs in 10 months.

The general average was very good, showing evenness over the pen.

This breed, as already mentioned, is strongly recommended for any locality and soil.

2.—*Faverolles.*

These have always been excellent layers here. They are not, however, general favourites with the average poultry keeper; the objections are the feathering on legs and the muffling round the face.

The average production of 18 birds for the above-mentioned period was 177·6 eggs per bird. No bird was outstanding in this

pen, the general average being very high. Only an odd bird now and again showed a desire to sit. Without care they might not do so well on the average farm in winter, especially if a very wet season. They are better suited to drier and warmer localities, unless the poultry keeper pays greater attention to shelter.

Faverolles have good white flesh and white legs. They fatten readily and make excellent table chickens. Crossed with the Buff Orpington, the progeny are good layers, also excellent table chickens, and mature very rapidly.

3.—*Rhode Island Reds.*

These, at the present time, are perhaps the hardiest of all the "General Purpose" breeds. The chickens are hardy and easily reared. Their egg production here has not, so far, equalled the White Wyandottes and Faverolles, but their hardiness and vigour go far to replace the loss of a few eggs, especially in an exposed locality where these points are essential.

They fatten well and make good table chickens, although the depth of the flesh on the breast does not equal that of the Wyandotte or Faverolle.

The flesh and legs of the Rhode Island Red are yellow. The single-combed variety is kept here, but the writer understands that the rose-combed variety is also very good.

The average production of 18 birds for the period already mentioned was 170·9 eggs per bird. Again there was no outstanding bird, but evenness over the pen.

4.—*Buff Orpington.*

These generally lay well here during the winter months. Our experience has been that it is necessary to have them laying well throughout winter, otherwise their average is low at the end of the season, as they are very troublesome with broodiness during spring and summer. They make quite the best sitters and mothers of the General Purpose Breeds.

The average egg production for the same period, viz., 1st October, 1912, to 31st September, 1913, was 138 per bird—low in comparison with the others, due to their broodiness during spring and summer.

Their flesh is white and they fatten well. When crossed with another breed, particularly a non-sitting breed, the broodiness is almost entirely eliminated. When crossed with the Houdan or Leghorn male bird, the progeny were found to give excellent results as layers, although the surplus cockerels were poor compared with the Faverolle crossed on the Orpington.

5.—*Buff Plymouth Rocks.*

These have not done so well here during the past season, in fact very little better than the Buff Orpington. They were also given to much broodiness during the spring and summer. They were slightly too large, and not enough of the smaller laying type of fowl, which we consider the better egg-producer. The production of 18 fowls for the period already stated averaged 142 eggs per bird.

They differ from the Buff Orpington in the colour of legs and flesh, these being yellow. The plumage is much the same. They are quite a hardy breed, and should do well in any locality. The strain of Buff Rocks here lay a very good-sized egg, deeply tinted.

6.—*Barred Rocks.*

These have been introduced for the coming season, and we hope that at the end of it they will have given a good account of themselves. As chickens they were found to be slow in growth, being big-boned and slow in feathering, which we consider a disadvantage in an exposed wet locality.

Egg Breeds.

1.—*Black Leghorn.*

This is a medium-sized breed of Leghorns, with combs which are not too large. They are hardy, active, and well suited for exposed localities, although, like all large-combed birds, they require more care during a sudden cold snap. They are poor as table chickens, but lay large eggs.

The average production for 17 birds for the period from 1st October, 1912, to 31st September, 1913, was 179·2 eggs per bird. Here, again, evenness was marked over the pen.

2.—*White Leghorn.*

During the season this variety did not hold its own, as regards egg production, with the black variety. They are larger in size and larger in comb, which has told against their egg production. We hope this season to introduce smaller-sized male birds, and thereby reduce the size of the progeny and increase the hardiness of the breed. The smaller active varieties should be as well adapted as the black variety for any exposed locality.

The production of 18 birds averaged 166·1 eggs per bird for 10 months. There was no outstanding layer in this pen.

3.—*Australian White Leghorn.*

These are also kept at the farm. Last season they were very late hatched, and did not start laying until December, 1912. They gave an excellent account of themselves afterwards, laying an average of 153 eggs per bird (18 birds in the pen).

They are at present very nervous, flighty birds, easily excited. One or two deaths occurred amongst them from ovarian trouble, due no doubt to injuries received flying about. They should do much better in this country when they become more climatized and more widely distributed. They will then not be so much inbred as at present. This shows, to a certain extent, in the rearing of the chickens.

Crosses.

The following crosses were also experimented with, and all proved excellent for laying :—

1. Houdan—Buff Orpington.
2. Black Leghorn—Buff Orpington.
3. Rhode Island Red—Faverolle.

1.—*Houdan—Buff Orpington.*

These were excellent layers. The average production for 16 birds for the period already mentioned was 180·9 eggs per bird. Only one or two were broody throughout the season. The surplus cockerels were very good table birds.

2.—*Leghorn—Buff Orpington.*

These were also very good layers, although their egg production did not equal the Houdan—Buff Orpington. They were much later hatched, and did not, therefore, get the same start off. The average production for 7 birds was 163·2 per bird.

3.—*Rhode Island Red—Faverolle.*

These were also very good layers. The production of 8 birds for 10 months was 147 per bird. They were mated with an Indian game male bird. The progeny were most excellent table chickens, maturing quickly, growing to a large size, and very vigorous.

This season the crosses being kept are a few Houdan—Buff Orpingtons and Buff Orpington—Faverolles.

FOODS AND FEEDING.

The requirements of poultry are :—

1. Grain food (whole and ground).
2. Green vegetable food.
3. Animal food.
4. Grit.

The food should always be in a fresh condition. It should be plain and wholesome, regularly supplied, and fed to the full capacity of the hen. The food given serves the purposes of repairing waste tissue, furnishing heat to the body, and supplying the egg-making materials. Only the surplus over what is needed for the body is available for egg production. The proper foods should, therefore, be given in sufficient quantities to induce egg production.

It is important that part of the grain food should be given in the form of ground meal, but this soft feeding should not be overdone, particularly when fed first thing in the morning.

No hard-and-fast rule can be stated as to the exact amount of food to be given to each fowl per day. The appetite varies according to—

1. Conditions of housing.
2. Season of the year.
3. Kind of fowl.

Fowls should be kept slightly hungry during the day, but should go to roost with well-filled crops.

The birds may be fed twice or thrice daily. In confinement, and on the free range in winter they are better fed three times.

With a long interval between feeding it is difficult to keep the birds off the perches. This often leads to bad habits, such as feather-eating, egg-eating, &c. The whole grain is fed to induce exercise, a certain amount of exercise being necessary for good health.

The soft mash may be given in the morning, followed at noon by a small quantity of grain, and a full feed of grain given in the afternoon.

For those who may find it more convenient to feed the soft mash later, the grain may be thrown into the litter in the morning, and the soft meal given at noon or in the evening.

In the case of poultry keepers who can only attend to their fowls in the morning, soft mash may be given, followed by sufficient grain for the remainder of the day.

The plan adopted here is to give the soft food in the morning, in the proportion of 1-ounce meals, &c., weighed dry, to each bird; about the same quantity of grain at noon, either cooked or dry; and a full meal of grain in the afternoon, which is practically 2 ounces per fowl. The grain is scattered into the litter on the floor of the scratching-shed, and in summer on the free range on the grass, choosing a fresh part each time. This method has always been attended with good results, providing the necessary exercise. The two rations used here are as follows:—

Ration No. 1.

This ration has been quite effective in the production of eggs in winter, the results of an experiment with it being given later.

The meals and grains used are easily obtainable by any class of poultry keeper :—

Quantity for 25 pullets—

Daily allowance,	4 ozs. each,
Total ,,	6¼ lbs.

Morning (7 a.m. in summer, as soon as clear in winter)—

Soft food,	1 oz. of each.
Bran,	6 ozs.
Oatmeal,	10 ozs.
Potato,	9 ozs.
Total,	25 ozs.

Noon—

Grain,	1 oz. of each.
Oats,	13 ozs.
Indian Corn,	25 ozs.
Total,	25 ozs.

Evening (3-4 p.m. in winter, 4-5 p.m. in summer)—

Oats,	25 ozs.
Indian Corn,	12 ozs.
Total,	50 ozs.
	or 2 ozs. of each.

Morning Meal.

The bran is scalded alone with boiling water, the potatoes, previously cooked, are added to the bran, along with the oatmeal—the whole made into a crumbly mass.

The raw grain is scattered into the litter.

Green vegetable food is supplied during the winter months, or at any time when grass is scarce. We consider a supply of green food absolutely essential for good health.

Ration No. 2.

This ration is also used here with much success. It has been very effective in the production of eggs in winter. The meals and grains used are easily procurable by any poultry keeper.

Morning (7 a.m. during summer, as soon as clear in winter)—

Soft food, - - -	1 oz. each.
Bran, - - - -	4 ozs.
Oatmeal, - - - -	8 ozs.
Thirds, - - - -	5 ozs.
Meat, - - - -	8 ozs.
Total, - - -	25 ozs.

Noon—

Grain, - - -	1 oz. each.
Oats, - - - -	13 ozs.
Indian Corn, - - -	12 ozs.
Total, - - -	25 ozs.

Evening (3-4 p.m. in winter, 4-5 p.m. in summer)—

Grain, - -	2 ozs. each.
Wheat, - - - -	35 ozs.
Oats, - - - -	15 ozs.
Total, - - -	50 ozs.

In feeding this ration, the soft food was also given in the morning, prepared as for No. 1.

The addition of meat, when procurable, increases the egg production in cases where fowls are kept in confinement, and also during the winter months when natural animal food, such as worms, snails, &c., is not available in the soil.

Part of the green vegetable food was chopped regularly and mixed in the mash, and, in addition, cabbages were hung up in the houses. They were hung sufficiently high to induce the birds to take exercise.

The grain given at noon during winter is mostly steamed, and when fresh meat is available it is cooked, and the stock produced is used instead of water for cooking the grain.

Fresh scrap meat from the butcher is used when procurable, at other times fish meal is used.

Soft mash should always be fed from troughs. These should be kept clean and hung up off the ground when not in use. The practice of throwing soft food upon the ground is not only wasteful but harmful as well. The ground becomes contaminated, and the food is mixed with excrement from the birds. Disease is often spread from this source. Wooden V-shaped troughs may be used. These should be washed regularly, and if they are kept dry they will last for a very long time.

Ration No. 3.

This ration permits of the use of waste from the kitchen, the waste distinguished as follows :—

Table.

What is left of porridge, potatoes, and other cooked vegetables, scraps of meat, bread, &c.

Kitchen.

Potato, turnip, and other vegetable peelings, which should be cooked. A surplus of water should be used in cooking the latter, into which the table waste and such meals as may be necessary to dry up the whole to a crumbly mass may be added.

The most suitable meals for use with waste products of this kind are bran and thirds. Take equal quantities of waste and meals, using either one or both of the meals.

At noon oats may be given, 1 oz. to each bird, and in the afternoon 1½-2 ozs. wheat per bird.

This ration will be attended with excellent results, and is most useful to the small poultry keeper. In addition, of course, green vegetable food should be given.

Clean fresh water must be supplied to poultry daily, in clean utensils, the chill removed in winter, and in summer the vessel containing the water placed in a shady place out of the sun's rays.

Grit, and especially oyster-shell, should be always before the birds, in a box where they will readily find it. Even on farms where fowls are at liberty and can find small stones for digestion, oyster-shell is necessary and valuable for shell formation.

The most valuable green vegetable we have found for winter use and for long keeping is thousand-headed kale, but cabbage, ordinary kale, and green leaves of any kind are valuable.

For toning the system and as a preventive of colds, the following tonic is very good :—

½ lb. sulphate of iron crystals.
½ oz. fluid sulphuric acid.
1 gallon water.

Use two tablespoonfuls to each gallon of drinking water occasionally. This is known as "Douglas's Mixture."

Milk—skimmed, separated, or sour or butter-milk—is excellent, and may take the place of meat in a ration, either by mixing the food with it or giving it to the birds to drink.

A mixture of Indian meal and potatoes should not be used alone as it is much too fattening and bad for egg production.

The Moulting Period.

This period is usually regarded as a season of non-production. Moulting is the shedding of the old feathers and the growth of new ones. It makes a heavy call on the fowl's system for proper material for the formation of the new feathers, and occurs at the end of the laying season, when the vitality is at its lowest.

During the moulting season the proportion of starchy foods should be reduced, and the ration should consist mainly of nitrogenous or flesh-forming foods. For example, the proportion of bran, thirds, and meat should be increased. At this season milk in any form is also most suitable, when available. In addition, the fowls should have an oily food supplied, such as pure linseed boiled into a jelly, and a little used almost daily, or linseed cake

meal. The addition of sulphur, one teaspoonful to six birds, on one or two mornings weekly is also beneficial, as there is a good deal of sulphur in the composition of feathers. Sulphur should only be given on fine mornings.

In some cases the moult is gradual and scarcely noticeable, and, in consequence, the birds may continue to lay throughout the period; in others it is rapid, the birds become almost naked, and laying ceases. Care must be taken that they are not exposed to cold or wet. Iron tonic is also beneficial for toning the system at this period.

Results of Feeding Experiments.

(*a*) *With 7 Pullets for 1 year from 1st November, 1912, to 31st October, 1913.*

They were fed on Ration No. 1, already described. Their eggs were sold at the current wholesale weekly market price obtained here:—

6 winter months, daily allowance,	4 ozs. each.
6 summer „ „ „	3 ozs. each.
Number of birds in pen,	7
Total number of eggs for year,	= 1,143
Average number of eggs per hen,	= 163·3
Average price per dozen,	= 1s. 4½d.
Total value of eggs laid,	= £6 3s. 10¾d.
Amount of food consumed, including grit,	= 537 lbs. 15 ozs.
Cost of food consumed,	= £1 17s. 2d.
Average cost of food per hen,	= 5s. 9¼d.
„ „ „ per week,	= 1·3d.
Profit over cost of food,	= £4 6s. 8¾d.
Profit per hen,	= 12s. 4½d.

(*b*) *With 252 birds for the Year ending 31st October, 1913.*

182 pullets laid	30,226 eggs.
70 second-season's hens laid	8,232 eggs.
Total number of eggs laid,	= 38,458
	or 3,204¾ dozen.

This works out at an average of 166 for the pullets and for the pullets and hens together, an average of 152·6 per bird.

The average wholesale market price for the year was 1s. 4½d. per dozen.

The total value of eggs produced, - -			= £220	6	6
Roughly the cost of keeping 70 hens, = £21	10	2½			
,, ,, ,, 182 pullets, = 62	15	0½			
Total cost of food, - -			= 84	5	3
This leaves a profit over the cost of keep, or 10s. 9½d. per hen.			= £136	1	3

These fowls were fed on Ration No. 2.

140 of these pullets were trap-nested for 10 months. This is an excellent method of finding out the best layers, but would not be practicable for a farmer, as it adds considerably to the labour. Trap-nesting is only possible on experimental farms or for specialists.

Four pens of the pullets were late hatched, not starting to lay before December, and therefore the total number of eggs for the year was reduced.

HOUSING.

Good housing is of prime importance for egg production. The function of food includes the maintenance of animal heat, so that the birds should not be exposed to conditions under which there will be undue loss of heat.

No matter how well-bred and well-fed the birds are they cannot give good results unless comfortably housed, and so that there is no waste of food. The essential points to observe are :—

1.—*That the house is plain but substantial.*

2.—*That there is a constant supply of fresh air without draught.*

The day of tightly-closed badly-ventilated houses is quickly passing, and modern houses are all more or less on the open-air principle. The amount of fresh air necessary depends upon

climatic conditions, but it must be such that where the poultry sleep and feed the air is perfectly sweet and free from taint. At least one-third of the front of the house should be wire-netted only, with perhaps canvas for protection from storms or for the regulation of air into the house.

3.—*Plenty of light.*

The house should have a southern exposure for the admittance of light, and especially sunlight, which is so valuable for poultry, particularly during the winter and spring. Disease, such as colds, roup, and tubercular trouble, is largely due to the want of light, fresh air, and cleanliness.

4.—*A dry floor.*

The house should be raised above the ground level to avoid dampness. It is impossible to keep fowls in cleanliness and health on damp floors.

For a fixed house the floor may be of wood or concrete, or similar material. The house should not be placed on the ground level, but raised some six inches above on a framework of wood, such as sleepers. As a preventive of rats, wire netting may be placed under the sleepers. The bottom is made up with ashes, covered with turf and soil, over which litter, such as chaff, dry leaves, sawdust, cut straw, or peat moss, may be scattered to provide a surface for scratching, and thus give the necessary exercise to the birds.

A portable house should have a wooden floor for the following reasons:—

(*a*) The house is drier and warmer.

(*b*) To prevent destroying the grass where the house is placed.

(*c*) The manure can be collected and distributed to greater advantage.

(*d*) There is greater security against vermin.

5.—*The amount of floor space per bird.*

This should not be less than 4 square feet for best results. If there is a separate roomy shelter attached, a smaller floor-space would do, say 2 square feet per bird. The house in this case is simply a roosting-house. Good results are never obtained from overcrowding.

The fittings should all be movable. Perches should be raised from the floor 3 feet; if higher, the heavy breeds cannot get up easily. The perches should be placed along the back of the house to keep the birds away from any chance of draught from the open front. They should be scrubbed with soap and water regularly, and the ends dipped in paraffin or creosote to keep down red mite. When droppings-boards are used they should also be movable for easy cleaning, and placed about half a foot below the perches. These boards should be sprinkled with a little dry sand, sawdust, ashes, lime, or peat-moss, to absorb the moisture, and thus prevent the droppings from soiling the boards, and also to facilitate cleaning.

Nest boxes, when entirely inside the house, should be made movable, and they should also be raised from the ground, say 2 feet, so as to give the largest possible floor space. They should be cleaned out and renewed with clean straw at regular intervals.

The house should be cleaned out whenever the litter becomes soiled or damp, and before it begins to smell of the droppings. The walls require treatment twice yearly. If it is a house built of wood treated with preservative, it should be washed and sprayed down with preservative such as creosote, which is cheap, costing about 6d. a gallon, and is excellent for keeping down red mite. If the walls are of untreated wood they should be lime-washed with the following:—

5 lbs. fresh lime shell.
$\frac{3}{4}$ lbs. salt.
$\frac{1}{2}$ lb. soft soap.
5 gals. boiling water, or enough water to make the whole of the consistency of cream.

The soap and creosote destroy and keep down vermin. The addition of a small quantity of painter's size will cause the wash

to adhere more thoroughly. This wash should be applied as hot as possible.

It may be found necessary during warm weather to spray rather oftener with creosote, or at least the grooves in which the perches rest, and also the perch ends, as the presence of red mite may prove very harmful to stock and considerably lower their vitality and, necessarily, their capacity for egg production.

Most of the poultry houses here are lime-washed twice or thrice yearly, with the exception of one or two which are made of wood treated with preservative, which are sprayed as already indicated, and we have had no trouble with mites and fleas in any house so treated.

In constructing a poultry house it should be made substantial. Too many poultry keepers are tempted to buy ready-made slim houses of $\frac{5}{8}$-inch match-boards. These are quite unsuitable for the climate in all parts of Scotland. They absorb moisture too readily in a damp climate, and during severe frosty weather they are frequently frozen and caked with white frost, which is extremely bad for the inmates. Houses should be made of $\frac{3}{4}$-inch or $\frac{7}{8}$-inch match-boards, built in sections and bolted together.

The house mostly used here has the highest elevation at the front. These are easy to build and give very satisfactory results. The illustration (p. 128) shows how air is admitted from the front, and is an excellent design for a portable house for use on the farm.

There are also a few American Tolmin Houses, which have a long slope to the front and the highest vertical point just behind the centre. These houses become too warm in summer, and require other means of ventilation as well as the wire-netted front for coolness in summer.

The ideal method of housing for the farmer with plenty of pasture land is the portable house. Portable houses take the birds away from the tainted farmyard, where poultry have run for generations. The fowls are healthier and more vigorous. Disease is less prevalent than where they are kept as one large flock about the farmyard. They obtain part of their own living from the pasture in the way of fresh supplies of grubs, worms, and other natural foods. This reduces the food-bill and increases

productiveness. They keep down injurious grubs, and by eating the seeds of many of the weeds. In these ways, and also by their excrement, the land is greatly improved.

To obtain the best returns from the portable-house system, the following points are worthy of attention :—

1. Not more than 20-25 birds should be in one flock. Larger flocks are invariably less satisfactory and yield relatively smaller returns.
2. Overcrowding should be strictly avoided. All good results to be obtained from this system will be entirely eliminated if they are overcrowded or by the want of cleanliness.
3. The house must not remain long on one place, as the ground soon becomes contaminated and the advantages of the system diminished.
4. Not more than 10-12 birds should be allowed per acre, in case of interference with the grazing of other stock.

Portable houses should be mounted on sledge-runners, which are preferable to wheels for easy moving, and they should be strongly made to withstand the strain.

There is no doubt that the fairly open-fronted house gives the best results—that the fowls are healthier, brighter in plumage, and the egg production good.

We would advise poultry keepers to keep only as many birds as they can attend to well.

We hope by another year to give the results of our experience with a flock of fowls kept under the Intensive Method, and its comparison with the portable house on the land and with the house and confined run.

See page 120.

WHITE LEGHORNS.

BLACK LEGHORNS.

HOUSE WITH PEN OF WHITE WYANDOTTES.

See page 128.

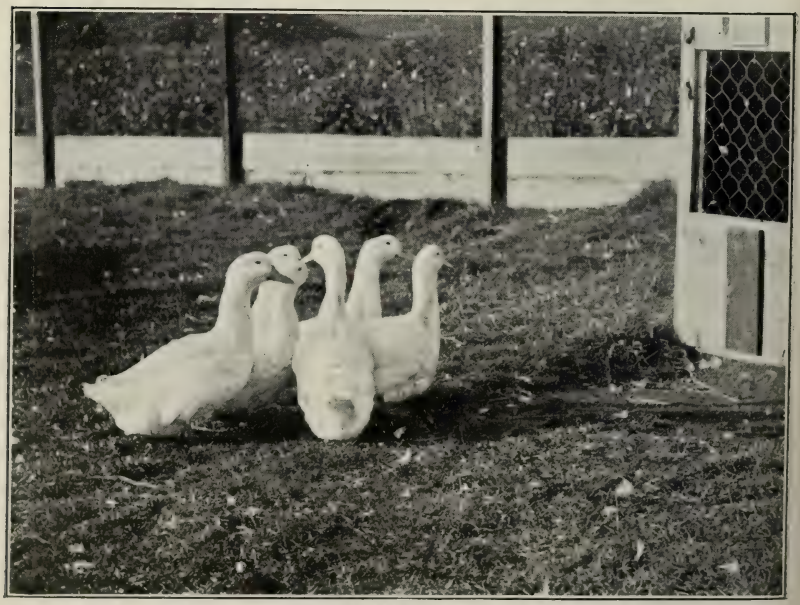
INTENSIVE POULTRY HOUSE.

See page 130.

See page 133.

AMERICAN BRONZE TURKEYS.

See page 137.



AYLESBURY DUCKS.

TURKEYS.

Turkeys should only be kept by farmers and others with plenty of ground and a free range. Successful rearing is most difficult where the space is limited. They may be kept in most parts of Scotland, but they do best in dry locations, and where the soil is not too heavy. It would be almost an impossibility to rear young turkeys on heavy clay soil in a wet season.

Light gravelly or sandy soils are excellent, but in a dry season both animal and green food may be deficient. Turkeys should also do very well on rich medium soil, where there will be a greater abundance of animal and green foods.

Turkeys are kept in much larger numbers in England and Ireland than in Scotland. In Ireland every assistance is given by the Department of Agriculture to encourage successful turkey breeding.

The breed best suited for Scotland is the Bronze American, which grows to a large size, and is hardier than other breeds.

To be successful it is important—

1. That the breeding stock should be strong and vigorous.
2. To select well-matured stock.
3. To avoid breeding from immature or unhealthy stock. Turkeys do not fully mature until two years old.
4. To avoid in-breeding. A fresh male bird from a reliable strain should be introduced every second season.
5. A young male and pullets should not be bred from in the same year.

Young hens, 16-18 lbs., and older ones of 20-22 lbs. weight, make the best layers and mothers.

Male birds, 30-36 lbs. weight, should be selected.

The selected stock should have long, straight, and deep keels, and a full breast, carrying as much flesh as possible. The legs should be fairly long, stout, and strong. Size is of importance in producing good birds for marketing at Christmas.

The birds should be typical in shape. The stock birds should not be in an over-fat condition during the breeding season.

The usual mating is 8-10 hens to 1 male. One impregnation usually fertilises the entire batch of eggs laid by a turkey hen, which generally lays from 20-30 eggs.

The first laid eggs may be set under an ordinary hen, but turkeys themselves make excellent sitters and mothers, and have far more understanding of the requirements and care of young turkey chickens than ordinary hens.

There is an increasing demand at Christmas for hen turkeys weighing from 10-15 lbs. Hen turkeys of this weight make the plumpest birds.

FEEDING OF STOCK TURKEYS.

In feeding turkeys starchy foods, such as Indian meal and potatoes, should be avoided. They should only have a light meal of soft food, consisting of bran, thirds, oatmeal, or biscuit meal and meat, in the morning, and in the evening chiefly good oats. During the breeding season their feeding should be largely hard food, in fact, hard food only could be given morning and evening, and more particularly when the stock are encouraged to roam over pasture, where they will find for themselves the necessary animal food. This latter method will keep the stock in much better condition and healthier for breeding from. Like other ordinary stock they consume a large amount of grit and oyster shell, which should always be within their reach.

HOUSING.

Turkeys would be much hardier and healthier if they were allowed to roost in trees or in the open, but this is not always possible or advisable. The house should be very roomy, in fact, quite an open-fronted shed, wire-netted only, to admit as much fresh air as possible. To keep out rain and snow and to keep the interior dry, the house may have its highest elevation to the back —say about 8 feet high at the back and sloping to 5 feet at the front. A shed made 10 feet long, and the same in width from back to front, will accommodate 10-12 adult turkeys, giving them sufficent floor space per bird. The perch should be arranged along the back of the house 3-4 feet from the ground, and the door wide

enough so that they can fly from the perches into the open. The roof should be made to project at least 6 inches over the front.

Turkeys should be housed by themselves and not along with the ordinary fowls.

HATCHING AND REARING.

This can be done by ordinary hens or by turkeys. An ordinary hen should be given 8 or 9 eggs and a turkey 18-20. After hatching is completed, the hen and young turkeys should be left alone for 24-36 hours, to allow the chicks to become quite strong on their legs before being removed to the coop, which should be a roomy one, as they require plenty of fresh air.

For the best results in rearing, it is important that the turkeys should have fresh ground and that they are reared by themselves, and not along with the ordinary chickens. The coops should be moved on to fresh ground every other day, and the grass should be kept short. Long wet grass is almost fatal to young chicks. They do better with shelter, and, if natural shelter can not be taken advantage of, it should be provided in the same way as for young pheasants.

At from a fortnight to three weeks old the hen and chicks may be allowed their liberty, at least for the greater part of the day. They should be fed on the pasture, and encouraged to stay there as much as possible.

The most trying period in their growth, after the first fortnight, is about the time they become fully feathered and the red coronculations appear on the head and neck. This is called "shooting the red," and takes place at the age of 8-10 weeks. Before this turkeys are very tender, but afterwards they are very hardy.

The mortality in rearing is due to indigestion, which causes diarrhœa and inflammation of the bowels ; and also to lice, to which the chicks are very susceptible, and droop very rapidly if the lice are present on their bodies. To prevent this, the hens should be very well dusted with pyrethrum powder before setting, again before they hatch out, and occasionally during rearing. The coops should be kept dry and clean, dampness being a cause of indigestion along with badly-prepared food. The mother and chicks should not be allowed out on grass damp with dew first thing in the morning.

FEEDING OF YOUNG CHICKS.

For two days no food. For the next few days stale bread soaked in milk and squeezed dry. Mix with it a hard-boiled egg and green food, both finely chopped. The green food may consist of onions (or their tops), lettuce, mustard, cress, dandelion, or young dock blades.

Curd made from milk is also excellent. It should be prepared as follows:—Take 1 gallon of either fresh separated or skimmed milk, heated to 84° F., and add to it 1 drachm of rennet. After standing for 45 minutes, put into a cloth and hang it to drain for 1-2 hours. When dry and crumbly it may be mixed with a little oatmeal or bread crumbs and fed to the chicks.

Later on they may be fed on a mixture of oatmeal, thirds, Indian meal, and a little biscuit meal, the latter scalded with boiled milk, and the other meals added to dry it off—green food, of course, should be added.

After the first fortnight or three weeks, turkeys may be fed much the same as ordinary chickens. They require grit, and when possible, milk should be supplied to drink instead of water.

For the first six weeks feed four times daily. From six weeks until twelve weeks feed three times daily, afterwards morning and evening. Allow the birds to roam during the day until the end of October. At this time any birds which are being kept or sold as stock birds should be selected and the others placed in a limited run for fattening.

To fatten feed three times daily; give as much as the birds will eat, two meals of soft food and one meal of grain.

We have had excellent results with the ration given below, producing turkeys at Christmas of excellent quality:—

½ part Bran.
1 ,, Indian Meal.
1 ,, Ground Oats.
1 ,, Fish Meal.
2 ,, Potatoes, or other scrap vegetables.

Turnip and potato peelings (boiled) from the kitchen.

During the last three weeks of fattening ½ lb. lard is allowed to 20 birds—the lard is melted and mixed with the food.

This mixture is fed morning and noon, and they are given a feed of mixed grain in the evening. They gain considerably during this period, and the quality is improved.

Before killing, turkeys should be starved for 30-36 hours, as they are generally hung, and are improved by keeping for a week or ten days after killing, when the weather permits. If the weather is cold and dry this can be done, but if damp and muggy a shorter time may be advisable.

Very few farmers who keep and rear turkeys sell them privately. They dispose of them direct to the poulterer, and the turkeys are therefore sold by live-weight.

We kill by dislocation of the neck, but many turkey-breeders think that they are better bled, and the flesh whitened by bleeding. We do not think there is much in this belief, and, as dislocation is simpler and does away with the mess of blood, we prefer to practice this method here.

Plucking and trussing for table is similar to the method followed with ordinary roasting chickens, and will be described later. With turkeys it is very necessary to remove the sinews from the legs.

DUCKS.

The best-known breeds of ducks are the Rouen, Pekin, Aylesbury and Indian Runner. The two latter breeds are the most useful for practical purposes.

Indian Runners are small light-bodied ducks, and are excellent layers. Their eggs are not much larger than hens' eggs. Where there is a good market for duck eggs they are the most profitable ducks to keep. They are active and splendid foragers, and on a farm with a free range they would easily find the greater part of their feeding throughout the year.

They are of no use for table purposes, being much too small. When crossed with an Aylesbury drake, however, they produce excellent table ducklings, quick in growth, and of a good weight.

By crossing, the poultry-keeper could both have the eggs for marketing and, if he is within reach of a good market for table poultry, he would be able to dispose of table ducklings, the ducks thereby serving a dual purpose.

The Aylesbury is known also as the white English duck, due to its pure white plumage. Their bodies are boat-shaped in appearance. They should have flesh or creamy-coloured bills and orange-coloured legs and feet. The Aylesbury duck is not such a good layer as the Indian Runner. At the farm here they lay on an average 94-100 per duck, which is considered very good for this breed. They are excellent table birds and mature very quickly. They are ready for killing at the age of 8-10 weeks, and, when they have been well fed, they will weigh at that age from 5-7 lbs. each. The result of an experiment on feeding ducklings for the table will be given later.

The Pekin Duck.—In appearance these are as large as the Aylesbury, but are not really, being more profusely feathered. They are different in shape. The breast is more upright and not boat-shaped like the Aylesbury. The plumage is not quite pure white, having a slightly yellowish tinge running through it. Their bills are a deep orange colour and also their legs and feet. They have the advantage of being rather better layers than the Aylesbury, but they do not have the quick maturity of the latter, taking 3-4 weeks longer to reach the same size. They are, therefore, not so suitable for table ducklings.

The Rouen Duck.—These have the same colour of plumage as the Mallard or Wild Duck. They are heavy and massive in body and mature very slowly. For table ducklings they are no use at an early age. They are better suited for killing in autumn and at Christmas.

There are other breeds of ducks of recent origin, which are said to be either good layers or suitable for table, or both combined, but we have had no experience of them.

Duck rearing is most suited for the farm poultry-keeper, more especially when egg production is the chief object, as the ducks have then the advantage of a free range. When kept for table purposes chiefly, the smaller poultry farmer could also keep them, as for this purpose range is not necessary.

They do best on soil which is light and gravelly. Although breeding stock can do without water on a free range, Indian Runners, when possible, will do better with a pond or running stream.

In mating ducks for breeding early in the season—that is, in January or February—not more than three ducks should be mated to one drake, as there is always great trouble with infertility of the eggs. Later on, from March onwards, five or six ducks may be mated to the drake, or even more with the Indian Runners. For early laying young ducks are best early hatched and well matured, but the stock may be kept during their second laying season as well.

The breeding stock should be kept during winter in good condition, without being overfat. They are excellent foragers, and the natural food obtained is helpful in maintaining health and vigour.

For laying they require to be given food containing a fair amount of flesh-forming material. The soft food given in the morning should consist of bran, thirds, meat, and green vegetable food. In the evening good oats or barley should be fed to the ducks in a trough with enough water to cover the grain.

They also require to have before them a box of grit, gravel, or coarse sand to aid digestion. For good results ducks require shelter during the night. Any existing shed could be utilised for this purpose and kept well littered with dry straw. If a house is provided specially it does not need to be made lofty, 3 feet in height would be sufficient, provided plenty of floor space per bird is allowed. To keep it dry it should be well raised above the level of the ground. Straw is more suitable than any other litter for the floor. It should be raked over daily and renewed frequently, as it readily becomes sour.

Hatching of duck eggs is more often done under hens, but they hatch quite successfully in incubators. When hatched they require very little brooding. They require to be kept dry and clean, and need plenty of fresh straw to sleep on. This should never be allowed to become offensive, otherwise disease may break out.

TABLE DUCKLINGS.

These should be hatched as early as possible in the season to get them on to the market early. For this trade they should be confined in small yards or runs in small lots, and given no access to swimming water.

The idea is to force growth, and, at the same time, the production of flesh, so that they will be ready at 8-10 weeks old.

For this trade they are only profitable when killed or sold off at this age. They are heavy feeders, and when kept for a longer period the profit is gradually reduced. Their condition will not be so good a week or two later, as they begin to cast their duckling feathers, and for a time the food is being used for the production of the new adult feathers.

Ducklings which are to be reared for stock birds should not be confined and forced in any way after three weeks old, and may be allowed swimming water.

FEEDING OF DUCKLINGS.

From Birth to 3 Weeks old.

Bran—Well scalded.

Biscuit meal—Well scalded.

Oatmeal or thirds added and a small proportion of sand or fine grit.

This mixture should be fed four times daily, or three times daily, and fine seed mixture soaked in boiling water in the morning and fed to the ducklings in the evening may be given.

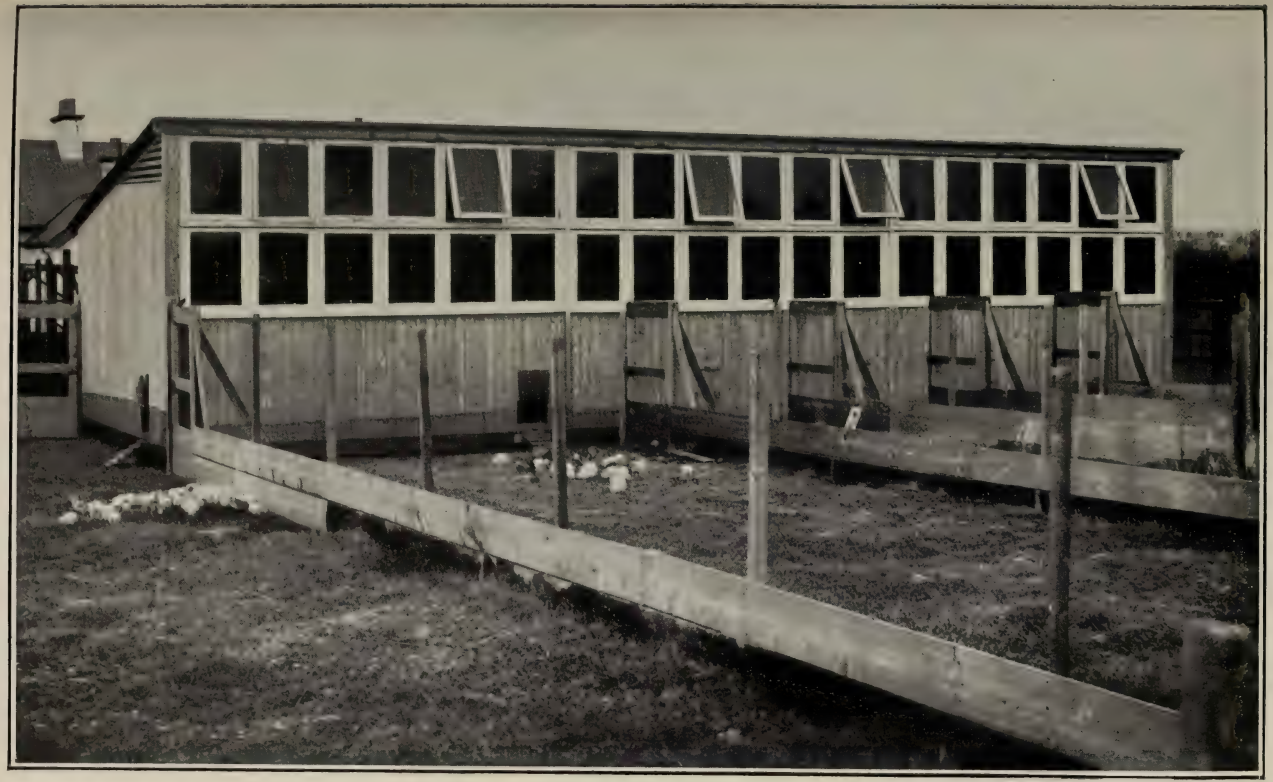
3 Weeks to 8 Weeks—for Table Ducklings.

A mixture of bran, thirds, Indian or barley meal, fresh meat, or meat or fish meal made into a soft mixture with milk or water may be fed. Green vegetable food, chopped, and added to the mixture.

They are given the above morning and noon, with grit or coarse sand.

In the evening a mixture of seeds which have been previously soaked in water, as follows: Wheat, cracked Indian, dari, and a smaller proportion of hemp.

The proportions for this mixture are given for rearing of chickens. Drinking water supplied.



WINTER BROODER HOUSE.

See page 152.

See page 160.

CRAMMING MACHINE.

See page 150.

FATTENING PEN.

RESULT OF FEEDING EXPERIMENT.

Cost of feeding 10 Ducklings until 10 weeks old—

20 lbs.	Bran, at 6s. 3d. per cwt.,	1s. 1¾d.
18 ,,	Oatmeal, at 34s. 6d. per 280 lbs.,	2s. 2½d.
26 ,,	Maize Meal, at 17s. ,,	1s. 7d.
8 ,,	Rice, at 18s. ,,	1s. 3½d.
17 ,,	Fish Meal, at 14s. 6d. per cwt.,	2s. 2d.
2 ,,	Biscuit Meal, at 18s. 6d. ,,	4d.
14 ,,	Thirds, at 8s. per 168 lbs.,	7½d.
12 ,,	Fine Seed Mixture, at 14s. per 112 lbs.,	1s. 6d.
22 ,,	Coarse Seed, at 8s. 6d. ,,	1s. 7¼d.
	Total,	12s. 5½d.

Cost of each bird for 10 weeks, - - - 1s. 6¾d.

One bird, - - - - 1¾d. per week.

Cost = 2d. a week, including grit.

INCUBATION.

1. The Selection of the Breeding Stock.

The stock should be produced from the eggs of healthy, vigorous stock. A fowl which has suffered from disease should not be allowed to produce offspring. Eggs from diseased fowls are seldom fertile, otherwise there would be more weakly birds in existence. The offspring from roupy birds are not likely to inherit this disease, but they are likely to have a weaker constitution and fall an easy prey to roup and other diseases. Therefore all fowls that are not strong and healthy should be discarded from the breeding-pen.

2. The Age of the Stock Birds.

Birds in their second laying season are better for breeding stock than pullets, for the reason that hens are more mature and do not lay so many eggs during winter. Consequently they do not lose in vigour so much before the breeding season. There is

no reason why pullets should not be bred from, if they have given a good account of themselves from October until March, and their eggs are available during their pullet years. The chickens from these eggs do not appear to lose in vigour or constitution. Pullets that have been late hatched should on no account be used as breeders. These do not generally attain the size of the particular breed at maturity, and have not laid much before spring. Their eggs are also much smaller.

3. The Care of the Breeding Stock.

Birds kept in ill-ventilated damp houses, or under any other insanitary condition, are lowered in vitality. This affects the germ of the egg.

They should be given variety in feeding, not too much soft food, plenty of outdoor exercise, as large a run as possible, and plenty of fresh air. Eggs from over-fat stock as a rule do not do well.

Birds kept on the portable-house system have all the above advantages, and consequently, as a rule, they produce eggs with much stronger germs.

4. Selection of Male Birds.

A good strong male bird which comes from productive ancestors should be used. Early hatched, well-developed, active cockerels should be used. Late hatched, immature, and badly nourished males are a decided hindrance to good progress. A good two-year-old male may be bred from, but it is necessary to remind poultry-keepers that a much smaller breeding-pen must be made up.

5. The Season at which Hatching should be done.

To obtain early-laying autumn and winter pullets, eggs from the heavier breeds, such as Orpington, Wyandotte, &c., should be hatched out during March. The eggs from the lighter non-sitting breeds should be hatched during the latter part of April and the beginning of May. When hatched very early in January or February the pullets will start egg production in August. They will lay for a month or two, then cease and go into a partial or complete moult.

The eggs of these pullets are, however, of great value at that particular season, when eggs are dropping off in numbers considerably, but they cannot be depended upon to lay during the latter part of October, November, and December.

On the other hand, very late-hatched pullets are too immature to start laying in early winter. They never attain a proper size, and their eggs have also a tendency to be small.

6. The Care of Eggs for Incubation.

Eggs must be gathered promptly during frosty weather in the early part of the year. It is all the better if they are collected twice daily to avoid the danger of freezing or the effect of very low temperatures in reducing the vitality of the germ.

On the other hand, in late spring, when broodiness is prevalent amongst the heavier breeds, it is not wise to leave the eggs too long in the nests under broodies. A few hours' heat is sufficient to give the germs a start, and this also reduces the vitality.

Eggs wanted for incubation should be kept at a temperature between 50° and 60° F. They should not be exposed to very low temperatures nor to a current of cold or heated air. If eggs are being kept for some time they should be partly turned each day during storage.

In packing eggs for hatching care must be taken to prevent injury during transit.

There is quite a variety of egg-boxes on the market, all of which are quite good, but the sender must use great care to have the eggs put in very firmly, so that they cannot move about, and cause the germ to be shaken up. Upon arrival at their destination, eggs should be put in a room kept at an even temperature, and allowed to remain undisturbed for 24 hours, to allow the germs to settle down. Displaced germs cause a good percentage of deaths in shell during the period of incubation.

SELECTION OF EGGS FOR INCUBATION.

Select eggs medium in size and as perfect in shape and colour as possible.

The selection as to size must be based upon the average product of the hen or breed. All abnormally large or small eggs should be rejected.

Freshness is very important. Fresh eggs hatch earlier and the chicks from them are stronger. As a rule eggs more than 12 days old should not be placed in an incubator. This point illustrates one of the advantages of a larger pen of 12-18 birds compared with a pen of 4-6 birds.

Eggs for hatching should be clean. When soiled the dirt closes up the pores and prevents free circulation of air to the embryo.

The eggs should be carefully washed in tepid water and dried with a clean soft towel. Washing does not harm the eggs, but it should be done carefully and quickly.

It is well to remember that eggs very fresh will hatch several hours earlier than those a week older.

Period of incubation—

Hen eggs, - - - - -	21 days.
Turkey ,, - - - - -	28 ,,
Duck ,, - - - - -	28 ,,
Goose ,, - - - - -	30 ,,
Guinea-fowl eggs, - - -	25 ,,
Pea-fowl ,, - - -	28 ,,

INCUBATION BY THE NATURAL METHOD.

The small poultry-keeper, and others who may not want to rear more than 100-150 chicks annually, will, as a rule, do so with hens. The chief difficulty experienced by all is the scarcity of broody hens during March. They are not plentiful before the middle of April, when it is too late to hatch out and rear the heavier breeds in time for winter laying. It is uniformity in age of the pullets which will fill the egg-basket during the winter months.

To those, therefore, who are following the natural process, an outline of the method practised at the Poultry Farm may prove helpful. An unused house is provided, with boxes placed round the sides of the building, and the available floor-space is covered with dry earth or sand, in which the sitting hens exercise and dust themselves when off for food and cooling of eggs.

Boxes are best 15 inches or 16 inches square, and the same in height. The front should be made to open out, so that the hens

will walk off and on to the eggs. This is better than having a box which opens on the top, in which case the hens have to jump down on to the eggs, and are liable to break them in doing so. These boxes should be made bottomless, and, to prevent damage from vermin such as rats, a piece of wire netting, half-inch mesh, should be tacked to the bottom. Above this a turf or sod should be placed, with the grass surface uppermost and the earth scooped out partly from underneath the centre, to make the turf basin-shaped or slightly hollowed. Above the turf a thin layer of hay or straw is placed, care being taken to have the sides of the nest well filled in, to prevent eggs from rolling into the corners of the box. The nest should then be dusted with pyrethrum powder alone, or mixed with flowers of sulphur.

A good broody hen, also well dusted with powder, should be placed on the eggs, but she should first be given one or two "dummy" eggs to test her for a day or two. Breakage of eggs during the incubation period is very often due to lice on the sitters. It is also due to interference by other birds, and hence it is advisable to carry on natural incubation in an unused building.

The hens most suited for hatching purposes are those belonging to the General Purpose and Table breeds. Buff Orpingtons particularly are reliable sitters and excellent mothers. Non-sitting breeds, and crosses bred partly from non-sitters, are all more or less unreliable as sitters, and in many cases would not sit out the hatch. They are also more nervous and flighty for handling.

During the sitting period the hen is taken off daily for food, water, grit, exercise, and dusting of her feathers.

Attend to the sitters as nearly as possible at the same time daily, to teach them regular habits.

The cooling during the time she is off is very beneficial to the eggs, causing much freer circulation of air and carrying off a greater amount of carbonic acid gas.

The time of cooling should be extended as the hatch proceeds.

The eggs may be cooled for about 10 minutes during the first week, 15 minutes the second, and 20-30 minutes the third week. The hen should be disturbed as little as possible when the eggs show signs of chipping.

The length of cooling must, however, vary according to the atmospheric temperature. When the hatch is completed, leave the hen and chicks alone for 24 hours. Before the chickens hatch out, however, the hen should be thoroughly dusted with pyrethrum powder.

After 24 hours the chickens will have had time to strengthen on their legs and can be removed to a roomy coop.

ARTIFICIAL INCUBATION.

Where chickens are wanted in large numbers before April, incubators become a necessity. They have been so much improved of late years that there are several kinds on the market which will give good results. They require little care. They can be regulated to maintain a fairly even temperature and are easily adjusted to meet the increase in temperature due to the development going on in the eggs.

The economy is great. There is less labour incurred in attending to a 100-egg incubator, compared with the management of 8 broody hens. Incubators can be started at any time.

At the Farm four different makes are in use, and we find very little difference in the final results from each. A table of these results is given below.

Whatever make of machine is used, a beginner should become quite familiar with it and run it for a few days before placing in the eggs. After the eggs are put in, adjustment of the regulating apparatus should be made with the greatest eare.

At the present time they are all constructed upon similar principles, and they derive their heat from lamps which burn kerosene or ordinary paraffin oil.

In hot-air machines the heat is maintained by means of heated air, while in hot-water tank machines the eggs get their heat from a water tank, into which heat is carried by means of a flue.

In the former the heat is diffused over and around the eggs in the egg-chamber, and in the latter the heat is radiated from the hot-water tank over and around the eggs in the egg-chamber.

It is unnecessary to enter into a detailed account of how to set up and start an incubator, as instructions are sent out with each machine. These enable the operator to set it up, and to regulate

it before putting in eggs. Remember, however, that success will depend upon accuracy and exactness and upon attention to the machine "on time" each day.

The following details in the management should be observed :—

1. The egg-drawer should be taken out in the morning each day, and the eggs turned with clean hands before attending to the lamp.
2. The lamp should be filled and the wick trimmed each morning, using only the best oil for the incubators. If the wick and chimney are not thoroughly cleaned the lamp will smoke, and a smoky lamp will result in a poor hatch.
3. During the first week of incubation the eggs should be cooled from 5-10 minutes in the morning, and only kept out in the evening during the turning of the eggs ; in the second week cool from 10-15 minutes ; and during the third week, until the nineteenth day is reached, cool from 20-30 minutes. The longer period of cooling should be in the morning.

   After the nineteenth day the eggs are not turned or cooled, and the drawer only opened occasionally to turn chipped eggs downwards. When the eggs are put into the incubator at first, the drawer is not taken out until the morning of the second day.
4. The temperature of the egg-drawer for good results may be, during the first week, 102° F., during the second week, 103° F., and during the third week, 104° F. Very high temperatures reduce the vitality of the chick, cause death in the shell, and often cause mortality amongst chickens in the very early stages of growth.
5. At the beginning of the hatch, the moisture-tray of a hot-water tank machine should be half filled with water at 80° F.

   The tray and canvas should be well washed, scalded and refilled with water at 80° F. once or twice weekly throughout the incubation period.

6. The room in which the incubator is placed is of great importance. The incubator should be placed out of draughts of any kind and so that it will not be disturbed or subjected to vibrations or jars. The door and windows of the room should be opened and shut quietly. The room should not be damp or dark, but direct sunlight should not fall on the incubator. The room should be light and airy, and with sufficient ventilation to keep the atmosphere of the room fresh.

The floor must be level and, if possible, of stone, brick, or concrete. A wooden floor will cause vibration.

An incubator should have a clean space around it, especially in front for taking out the egg-drawer, and also a space at the lamp side.

A northern exposure is ideal when possible to have it. All eggs, both in incubators and under hens, should be tested on the seventh day of incubation for fertility. To do this successfully the room must be darkened.

An egg-testing lamp can be used, or testing can be done by means of ordinary candle-light, and a square of cardboard with an opening the shape of an egg cut out of the centre. The opening should not be quite as big as the egg itself. The egg is placed against the opening in the cardboard and held up against the light.

Egg-testers are generally sent out with each incubator and fit on to an ordinary small paraffin lamp. Before taking out the eggs for testing have everything in readiness—table, lamp, or candle, and a tray to take the eggs as tested upon the right, also a basket for infertiles. The egg-drawer is then taken out and placed upon the left.

The eggs are tested one by one. If fertile, place in the empty tray; if infertile, in the basket. When finished, the fertile eggs are put back into the drawer and placed in the machine, or, if from hens, under hens again. Experience very soon teaches the difference between fertile, infertile, and doubtful germs.

The fertile egg shows a dark moving speck in the centre with a network of lines or threads surrounding it. This speck floats

as the egg is turned round. Such eggs are good and the germs alive.

Some eggs may show a stationary dark spot, others a single red line running lengthwise of the egg, or forming a semi- or complete circle. The former is a dead germ and the latter indicates a broken yolk. These should all be removed, otherwise they will eventually foul the air of the egg-drawer.

Infertile eggs are clear and have the appearance of eggs which have not been subjected to heat. These are removed and are still quite suitable for cooking purposes, or for feeding to young chicks. Infertile eggs cool quickly, and they absorb heat from the air of the egg-chamber.

Economy can be practised by removal of infertiles from under hens.

A second test may be taken at the fourteenth day of incubation, removing all eggs which have not advanced much further since the previous test.

These decompose, giving off poisonous gases, and are harmful to the live embryos in good eggs. This test is unnecessary when hatching with hens, and should only be undertaken by poultry-keepers with experience in testing, as mistakes might sometimes be made.

A record should be kept of each hatch, whether hatching with an incubator or with hens.

The following headings would be sufficient :—" Number of eggs set. The kind of eggs. Temperature of egg-drawer, morning and evening. Temperature of room, morning and evening. Number infertile, seventh day. Number dead in shell. Number hatched."

The average percentage of chickens hatched from the hot-water tank machines at the Farm worked out for 1913 at 63·5 per cent. of the total eggs, or 78·5 per cent. from fertile eggs.

The average percentage of chickens hatched from the hot-air machines was 57·5 per cent. of the total eggs, or 71·1 per cent. from the fertile eggs.

The average percentage of chickens hatched under hens was much higher, working out at 82 per cent. of the total eggs set, or 91·5 per cent. from the fertile eggs after testing.

It has to be borne in mind that the incubators at the Farm are all handled by students for educational purposes, and that they are subjected to a great amount of extra handling and disturbance.

The hatching period with the incubators extends from the beginning of January until September. Hens are only used during the busier hatching season, chiefly in April and the earlier part of May. The cost of working a 100-egg incubator is roughly as follows :—

2 gallons paraffin, at 10d. per gallon, - - 1s. 8d.

The cost of keep for 1 sitting hen for 21 days :—

Average quantity of food consumed daily, 1½ oz.

Or 1 lb. 15½ oz. for 3 weeks. Equal parts wheat and maize, at 17s. and 16s. per 280 lbs.

Total cost for the period = 3d.

Or 1s. 9d.—2s. for 7 or 8 hens to hatch out 100 eggs.

The cost of either method is therefore much the same, but the labour connected with the hens is greater than for the incubator.

After the hatch is completed, and the chickens have been removed from the nursery, the machine should be carefully cleaned and set right for future use.

At the end of the hatching season the tank of a hot-water tank machine should be emptied, and the lamp kept going for a day or two with a very low flame, to dry out the tank thoroughly. The lamp should then be emptied of paraffin and left thoroughly clean.

It is gross carelessness, and very bad for an incubator to be set aside without cleaning out, and to be found in this condition at the beginning of the next hatching season.

NATURAL REARING.

When chickens are being reared with hens, a supply of small coops are needed. These coops are generally made about 2 feet square, sloping from front to back. The higher elevation is at the front, which is 2-2½ feet in height, sloping to 15 or 18 inches at back. They are made with a movable floor, which is pulled out from behind and permits of easy cleaning. The front of the coop is slatted, the middle spar adjusted to pull up so that access can be had to the hen when necessary. The roof of the coop is best made solid—it will be drier. Coops should be placed in a sheltered location. They should be moved a short distance daily, or at least every other day, to prevent destroying the grass under and around the coop, also to provide fresh grass for the hen and her brood.

The coop should be placed with its back to the wind, so as to keep the chickens warmer on stormy and wet days. Any small detail which will mean more comfort to the chickens should be attended to, and will ensure better results in rearing. Chickens allowed to become wet and comfortless in their quarters will not thrive so well and will consume more food to keep up the body heat.

It is also necessary to keep the coops clean and dry, as chickens breathing vitiated air in the night-time are lowered in vitality and become fit subjects for gapes and other chicken ailments, which will prove very troublesome.

Care must also be taken to prevent lice getting upon the chickens. The hen should be dusted weekly with plenty of insect powder, care being taken that it reaches the skin. By keeping the hen free from vermin, the chickens will not be liable to have them, especially if they are otherwise healthy.

A mother may be taken away from her brood at the end of six weeks, when the chickens should be placed in a chicken-house, well littered with straw. This straw should be tossed up daily and renewed when necessary. Right through the rearing period it is necessary never to neglect to keep everything in connection with the birds clean. It is quite as necessary to observe cleanliness with feeding and water dishes.

ARTIFICIAL REARING.

The brooder should be got into good working order a day or two before the chickens are to be placed in it. It should be clean, dry, and well littered with peat moss, sawdust, cut straw, or chaff—indeed any material which will be soft and comfortable to the chickens.

The temperature of the brooder is best at 90°-95° F. during the first week, 85°-90° during the second week, and then gradually reduced according to the outside temperature. Care must be observed that the brooder is not too warm or too cold; coldness will cause the chickens to crowd together. Either way is very bad for them, and is almost certain to cause diarrhœa or bowel trouble, which is often a dreadful scourge among brooder chickens. They should be placed in the brooder when about 24 hours old.

During the very early part of the season it may be found necessary to at first to keep the brooder in an unused shed or building for shelter.

THE CARE OF THE CHICKEN-REARING GROUND.

On a farm, where possible, fresh rearing ground should be used annually. This is of the greatest benefit to chickens, and an advantage which farm poultry-keepers have over poultry-keepers with a limited space. When the same ground is being used yearly, the greatest care must be exercised to prevent it from becoming exhausted or foul.

All the points already mentioned with regard to moving of coops and brooders daily, feeding from dishes, &c., should be observed. Food should never be thrown on the ground, as this would be a source of contamination. The grass should be kept short during the rearing season, and in the autumn or winter the ground should be given a thick dressing of ground lime. This has been done here yearly, and since the department was instituted there has been no mortality from gapes or other contagious diseases.

FEEDING OF YOUNG CHICKENS.

Chickens require no food until 36-48 hours old. During this period they are resting and slowly digesting the yolk-food which was absorbed into their systems before they emerged from the shell.

It is important that young chickens are not allowed to have too much food during the early period of their growth.

There is no general agreement at present as to the best method of feeding. We have tried different methods of feeding here. The most useful of these methods follow :—

Method No. 1.

Infertile eggs are boiled hard and then chopped fine, shells included ; then mixed with 4 times their bulk of bread-crumb or oatmeal. These are rubbed together and no other moistening is necessary. This is fed for 2 or 3 days on small flat wooden boards. Chicken grit is given. On the 3rd day the chicks are given a mixture of seeds and grains, the latter finely broken and sifted.

The mixture used is as follows :—

Cracked Wheat, - - -	5	parts by weight.
,, Indian Corn, - -	2	,, ,,
Pinhead Oatmeal, - -	3	,, ,,
Broken Rice, - - -	2	,, ,,
Canary Seed, - - -	3	,, ,,
Hemp Seed, - - -	1	,, ,,
Equal to 1 cwt., - - -	16	

1 part = 7 lbs.

This is thrown amongst the litter to brooder chickens, care being taken to limit the quantity to their needs, and to prevent waste. It is fed first thing in the morning.

Several of the prepared dry chick-feeds on the market may be used. They are all right when made of good clean broken grain and seeds. When only a few chickens are being reared it will be convenient to buy the prepared feed, but when many are raised it is less expensive to use home-mixed feeds.

At 9.30 the soft food mixture is fed, prepared as above. Allow the chickens 5-10 minutes to eat, and then remove the boards.

At 12.30 the seeds are given, and at 4.30-5 p.m. give them as much as they will eat of the soft food.

After a week the egg mixture is gradually displaced by a mixture as follows :—

Bran, - - - - - -	2	parts by weight.
Biscuit Meal, - - -	1	,, ,,
Thirds, - - - - -	2	,, ,,
Indian Meal or Oatmeal, -	3	,, ,,

Beef scrap, dried meat meal, or fish meal, 1 part.

The biscuit meal and bran are previously scalded, and so also are the dried meat meal and fish meal when used. The other meals are mixed with these, and the mixture kept in a moist crumbly state for feeding.

Small wooden troughs are now used instead of the flat boards.

The above mixture is fed twice daily, chick-feed being given at other times.

The digestive organs and particularly the gizzard must not be allowed to become weak by disuse, as would happen if soft food only were given.

When 6-8 weeks old, a coarser and less expensive dry seed mixture is given. It is as follows :—

Whole Wheat, - - -	8	parts by weight.
Roughly-cracked Indian Corn,	4	,, ,,
Dari, - - - - - -	3	,, ,,
Hemp Seed, - - -	1	,, ,,

Method No. 2.

Infertile eggs are omitted, and the following mashes used :—

Mash No. 1—Biscuit Meal, -	1	part by weight.
Oatmeal, -	2	,, ,,
Thirds, - -	1	,, ,,
Meat scraps, &c.,	½	,, ,,

Biscuit meal and meat meal, when used, are scalded together and other meals added.

If the whole lot of meals are scalded together the mash is likely to be very sticky.

Mixing in the way indicated has been found to greatly improve the mash.

This soft mash is used instead of No. 1, and the same mixture of dry chick-feed used.

NOTE.—Biscuit meal, when it can be bought reasonably cheap, and after being well scalded, is excellent for chick growth. It is also useful for making bulk, and for keeping the mixture in a nice crumbly condition. If not used, or after three weeks' use, bran may be given instead, and it should be scalded alone, just as in the case of the biscuit meal.

Mash No. 2—Consists of a mixture of the following seeds, which are steamed the day previous to using :—

Cracked Wheat.
„ Indian Corn.
Pinhead Oatmeal.
Rice and Linseed.

For 6 lbs. of this mixture 3 quarts water are required for proper cooking. When cooked this may form a meal by itself. Here, because of the large number of chickens, we use it mixed along with the other meals.

This cooked seed mixture is excellent for growth and feathering, and, where possible, we advise its use from one to six weeks old.

We have always experienced difficulty in rearing chickens entirely on dry chick-feed from the beginning, especially during January, February, and March, but have done so with marked success during late summer and autumn, due, no doubt, to the fact that the chicks get out on the ground much more. They work harder and are able to digest the chick-feed better when dry food is used entirely. The chickens should be given once a day a small feed of beef scrap. A box of fine chicken grit should be in front of the birds at all times.

Milk or water is given in limited quantities for the first fortnight. When milk is used—which may be skimmed or separated, soured or buttermilk—less meat may be used in the mixture.

It is not necessary to supply chickens with green food, except when they are being reared in confinement, or when reared on small limited runs where there will likely be very little grass.

Any fine green stuff may be used—lettuce, dandelion, dock, mustard, cress, &c.

FEEDING HALF-GROWN CHICKENS.

When the chickens are about 3 months old the sexes are separated.

The method of feeding the cockerels and pullets differs.

On a farm the pullets are put out in the fields, in portable houses, where they will have full benefit of fresh ground and plenty of roaming, which are excellent for their growth and future vigour. These may be given grain food only morning and evening, and kept in this way until they are placed in their winter quarters towards the end of September.

This method lessens the cost of feeding and labour in attending to the birds. On more confined areas a meal of soft food is given in the morning, followed at noon and evening with grain only.

The morning mash consists of—

Bran (scalded), - - -	4	parts by weight.
Thirds, - - - -	2	,, ,,
Indian Meal, - - -	4	,, ,,
Linseed Meal, - - -	1	,, ,,
Beef Scrap, &c., - - -	1	,, ,,

The meat supplies the deficiency of natural animal food and the linseed is excellent for feathering.

Cockerels that are good enough to sell as stock will do much better if treated in much the same manner as the pullets; but, when being sold off for table purposes, they may be kept in confined areas, and fed 3 times daily—morning and noon on soft food mixtures and on grain in the evening. This method of feeding will hasten growth and production of flesh at the same time and they may be sold out as soon as they are ready.

They are generally in good condition from 12-16 weeks old, without any special fattening, when fed as above.

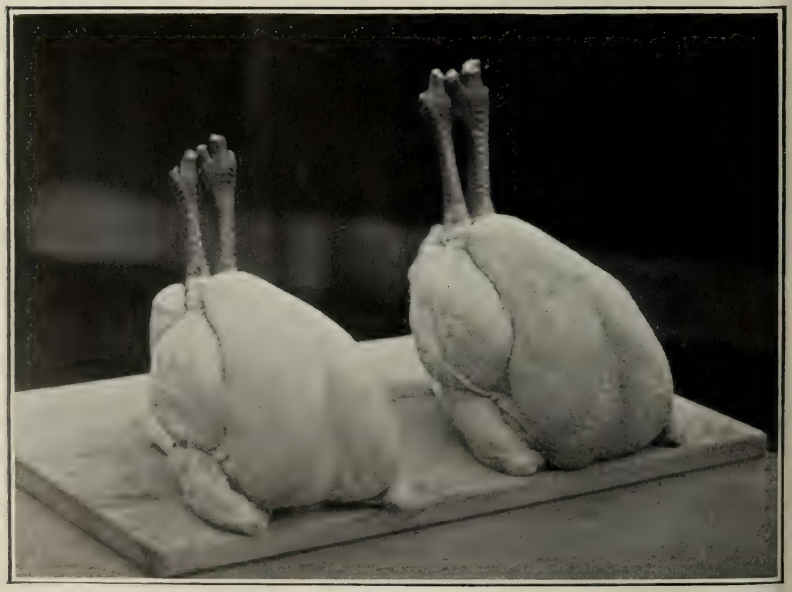
FIRST PROCESS OF TRUSSING.

TAKING OUT ENTRAILS.

See page 169.

See page 170.

SECOND PROCESS IN TRUSSING



TRUSSED BIRDS.

In the spring of 1913, an experiment was carried out at this department to find out the cost of feeding chickens, from birth until 16 weeks old.

Sixty Rhode Island Red Chickens were hatched on 17th February; 55 of them were reared to 8 weeks old in brooders.

The amount of food consumed during that period was:—

20½ lbs.	Biscuit Meal, at 19s. 6d. per cwt.,	3s. 6½d.
7 lbs. 1 oz.	Pinhead Oatmeal, at 15s. „	11d.
3 „	Canary Seed, at 22s. per cwt.,	6¾d.
50 „	Fine Seed Mixture, at 14s. per cwt.,	6s. 3d.
18½ „	Cooked Seed, at 12s. 6d. „	1s. 5¼d.
3½ „	Thirds, at 9s. per 168 lbs.,	2¼d.

Total quantity of food consumed = 112½ lbs. for the period of 8 weeks.

Value = 12s. 10¾d., or 2¾d. per chick.

Add to this amount the cost of paraffin burned in brooder lamp for a period of 6 weeks = ¾d. per chick.

Total cost, 3½d. per chick.

At the same time 12 Rhode Island Red Chickens were hatched out on 22nd February. These were reared by the hen to 7 weeks old.

The amount of food consumed by them was as follows:—

8 lbs.	Biscuit Meal, at 19s. 6d. per cwt.,	1s. 5d.
4 „ 2 oz.	Pinhead Oatmeal, at 15s. per cwt.,	6d.
14 „ 7 „	Fine Seed Mixture, at 14s. „	1s. 9¾d.

Total quantity of food consumed for above period, 26 lbs. 9 oz., at a cost of 3s. 8¾d., or 3¾d. per chick.

The feeding of the hen is charged against the chicks.

The mother was then taken from the chickens, and the latter reared along with the brooder chickens, making a total number of 67 chickens.

Amount of food consumed during the next period of 4 weeks was :—

20¼ lbs.	Bran, at 6s. 3d. per cwt.,	- -	1s. 1½d.
20¼ „	Thirds, at 8s. per 168 lbs.,	- -	11½d.
20¼ „	Oatmeal, at 34s. 6d. per 280,	- -	2s. 10d.
65 „	Cooked Seed, at 12s. 6d. per cwt.,		6s. 11½d.
144 „	Coarse Seed Mixture, at 8s. 6d.	„	10s. 11d.
9 „	Fish Meal, at 14s. 6d.	„	1s. 2d.

Total amount of food consumed, 276¾ lbs. ; at a total cost of 23s. 11½d. for 4 weeks, or ¾d.-1d. per head per week.

Note.—Three chickens died during this period.

During the next period of 4 weeks the cost of feeding was as follows :—

37¾ lbs.	Bran, at 6s. 3d. per cwt.,	- -	4s. 2½d.
17½ „	Fish Meal, at 14s. 6d. per cwt.,	-	2s. 2¼d.
57¾ „	Oatmeal, at 34s. 6d. per 280 lbs.,	-	7s. 1½d.
57¾ „	Thirds, at 8s. per 168 lbs.,	- -	3s. 1d.
42 „	Maize Meal, at 17s., at 280 lbs.,	-	2s. 6½d.
149 „	Coarse Seed Mixture, at 8s. 6d. per cwt.,		11s. 3¾d.
50 „	Cooked „ „ 12s. 6d.	„	6s. 5d.

Total amount of food consumed, 411¾ lbs. ; at a total cost of 36s. 10½d.

Cost of feeding one chicken per week, - 1s. 0½d.

Note.—The chickens were then 16 weeks or four months old on the 10th of June. Cockerels which were mismarked and only fit for killing purposes were selected out.

The total amount of food consumed from birth to 16 weeks old was 829 lbs. 9 oz., at a total cost of £3 17s. 5½d., or 1s. 2½d. per chicken for 16 weeks.

The mismarked cockerels which were selected out for killing were weighed on this date, and were found to weigh, on an average, 4 lbs. each.

A few cockerels were kept for stock purposes, and all the pullets are laying stock.

Note.—The amount of grit consumed has been inadvertently omitted, but may be taken as ½d. per chicken over the period.

We are again to conduct feeding experiments during 1914.

FATTENING COCKERELS FOR MARKET.

The greater proportion of cockerels in Scotland are sent to the market alive without being fattened. The selling of lean chickens is wasteful. Experiments which have been carried out at this department show quite clearly that keeping the cockerels on special feeding for a few weeks before killing adds considerably to their selling price. All surplus cockerels not considered good enough to sell as stock birds are fattened and killed off, as well as all chickens specially crossed for table purposes.

The different methods by which poultry can be fattened are as follows:—

(1) By keeping the birds in very limited pens, so that they will have little exercise.

Fed three times daily on soft food, and water to drink only during their meals. 12 to 18 birds may be kept together.

(2) By confining the birds in fattening coops.

The coop is generally made 6 feet long, 18 inches high, and 18 inches wide. It will hold a dozen birds; but it is better to divide the coop into two or three sections, to hold 3 or 4 birds each.

A little room for the birds to move about is all that is necessary, as the less exercise they have the more readily will they fatten.

The top, back, and ends of the coop should be solid for outdoor use. It is possible to have them outside in a cool, shady spot in summer and autumn. At other times they will fatten best indoors. The front of the coop is made of round spars. These spars should be 2 inches apart, to allow the birds to eat from the trough which is hung in front outside the coop. The bottom of the coop should also be made of rounded spars, placed 2 inches apart; and as the coops should be raised from the ground 2 or 3 feet, the droppings will fall through on to the floor underneath, which should be littered.

The birds are fed twice or thrice daily on soft food mixtures, which will be given later.

(3) Machine Cramming.—This is carried out in combination with No. 2 method of fattening.

The birds are trough fed for a fortnight, and then crammed for a week or ten days before killing.

A cramming machine is necessary.

The result of an experiment will be given to show that a system of trough feeding alone will produce birds equal in weight to those which have been crammed.

(4) Hand cramming or pellet cramming can be done, but it is very laborious work where many birds are being fattened.

The food is made stiff; formed into pellets about 2 inches long and $\frac{1}{2}$ inch in thickness.

A sufficient number of pellets should be prepared before cramming commences.

The operator sits on a stool, holds the bird firmly between the knees, and stretches out the neck, holding the mouth open. The pellet is then dipped in milk or water, placed at the back of the mouth, and is

pressed into the gullet with the finger. The neck is then gripped above the pellet with the finger and thumb, and the pellet is forced into the crop. It will take a good number of these pellets to fill the crop, depending on its capacity.

Food for Fattening Birds.

It is quite easy to produce good chickens. Good cockerels, either pure bred or crosses of breeds, such as the Orpington, Wyandotte, Plymouth Rock, Faverolle, Dorking, Game, &c., will make economical gains.

Breeds such as Leghorns, Minorcas, and other birds of a similar nature, do not lend themselves to fattening, and make very indifferent roasting chickens.

When game birds, such as the Indian Game or Old English Game, have been used for crossing, the pullets should also be fattened off for table purposes. The birds usually make their greatest gain when from 3 to 4 months of age, when they will weigh from $3\frac{1}{2}$ to 4 lbs. each. To allow a bird to range much longer before fattening the gain will not be so profitable, and it may be difficult to get a higher price for the bird.

Usually, birds when put up for fattening make the greatest gain during the first two weeks of feeding.

The period of fattening should not extend over 21 days, as after this period the added gain is not sufficient to justify the extra expense of feeding.

When fattened indoors the room or shed should be kept darkened, except during meals, to keep the birds as quiet as possible.

The fattening coops should be lime-washed or disinfected regularly, and when the birds are put into the coops they should be well dusted with pyrethrum powder and sulphur to kill and keep down lice. They should not have water to drink, unless during very hot weather.

During the first week of fattening feed lightly, that is, rather underfeed than overfeed the birds; gradually increase the amount of food until the birds refuse to eat all given them. No food should be left in front of them longer than 10 minutes after it is placed in the trough; any left over should then be removed.

It is of great importance that the birds be kept with keen appetites.

As it is difficult to give a ration suitable to meet the requirements of all poultry-keepers, we are giving several which will be of use:—

No. 1.

Ground oats mixed with soured milk. This is considered one of the finest foods for fattening.

Note.—The oats should be finely ground, husk and all. The presence of the husk aids digestion.

No. 2.

Equal parts ground oats or oatmeal, barley meal, and Indian meal, with soured milk.

Note.—Barley meal, when containing a large amount of coarse husk, should be sifted before use.

No. 3.

1 part oatmeal.
1 ,, Indian meal.
$\frac{1}{4}$,, fish meal.

The fish meal is well soaked, and the other meals added to it. To bring the mixture to a proper consistency milk or water may be used.

It is always a very great improvement to the mixture to use milk when it can be had, and especially if the milk be

soured. The acid has the effect of whitening the flesh. When milk cannot be had, the No. 3 mixture is good, or meat in some form could be added to the other mixtures.

Fattening food is best prepared at least 12 hours before use.

The use of a large proportion of Indian meal has a tendency to cause a deposit of soft yellow fat in the system, which largely disappears during cooking.

The food should not be made stiff. Milk or water should be added to make a batter, usually in the proportion of 2 lbs. milk to 1 lb. of meal.

The ration which we have used freely with marked success for some time is No. 3. We feed it to the birds morning and noon, and in the evening they are given a feed of grain, wheat and oats, and allowed water to drink along with the grains only.

We give below the result of an experiment with birds fed on No. 3 ration. They were fed thrice daily, and compared with birds fed on No. 2 ration, omitting the barley meal, which was fed twice daily during the first 11 days, and the birds then crammed for 10 days.

Fattening Experiment.

No. 1—6 birds in the pen.

Food consumed—

10½ lbs. oatmeal.	
10½ „ Indian meal.	
5¼ „ fish meal.	
11¾ „ oats.	
Total cost for 3 weeks, - - -	7½d. per bird.
„ weight of birds before fattening,	28¼ lbs.
„ „ „ at the end of the fattening period,	41½ lbs.
Average gain per bird, - -	2 lbs. 3½ oz.

No. 2—6 birds in the pen.

Food consumed—

19 lbs. oatmeal.
19 ,, Indian meal.

Total cost for 3 weeks, - - -	7¼d per bird.
,, weight of birds before fattening, -	27¾ lbs.
,, ,, ,, at the end of the fattening period,	39½ lbs.
Average gain per bird, - - -	2 lbs. ⅔ oz.

On each occasion that we have tried the two methods together the results have always been in favour of No. 3.

The object of fattening is to make the chickens more fleshy, with just sufficient fat to make them cook well. It is not intended to make them abnormally fat.

Marketing Poultry.

A large part of the profit in poultry-keeping depends on the marketing of the products. The producer should therefore consider the market demands, and dispose of the products to the best advantage.

In killing and dressing for the market an attractive appearance is of prime importance. The producer should learn properly the details of killing, shaping, dressing, and packing, in order to despatch the products in the best possible manner.

As this work cannot very well be learned from books, advantage should be taken of practical instruction given by the Extension Instructresses or at the College Poultry Department.

Killing and Shaping.

All fowls should be fasted from 12 to 24 hours before killing. Where this is not done the food decomposes in the crop and intestines, causing discolouration and tainting of the flesh; also the birds do not keep so well.

PLUCKING.

KILLING BY DISLOCATION.

See page 165.

See page 166.

METHOD OF SHAPING.

CUTTING OUT CROP.

CUTTING OUT NECK.

See page 167.

See page 168.

The method of killing adopted here is by dislocation.

The bird is held by the feet and wings in the left hand; the head is taken in the right hand between the first two fingers, the neck is stretched, and at the same time it is given a quick turn backwards. This method is expeditious, and there is no mess, as the blood collects in the loose skin behind the head.

After killing, plucking should begin at once. The operator should be seated, and the bird should be held head downwards, to allow the blood to drain from the body into the space behind the head.

It is more expeditious to pluck fowls warm than to allow them to become cold. When plucked immediately the skin is not so readily torn. The bird should be plucked clean, removing with a blunt knife all pen feathers or stubs.

Shaping.

After plucking, and whilst the joints are still flexible, the fowl should be tied down, to give it a compact appearance. The method of tying is as follows:—

Take two pieces of string, 8 inches in length. Tie one to the middle toe of each foot.

Fold the legs back by the sides of the breast. Take the strings underneath the wings round to the back, pull tightly to keep the legs close by the breast, and tie.

Another piece of string, about 18 inches long, is passed through at the double hock joints under the end of the breast-bone or keel. The string is crossed behind the hock joints, taken round the tail, and tied at the back of it firmly, to bring the hock joints and tail together. It is then placed on its back with the head hanging down, and allowed to cool before being drawn and trussed.

Drawing and trussing is done as follows:—

First of all cut away the strings used for tieing down or shaping. Then singe the bird. For this methylated spirit is best. It does not blacken the skin. Failing the use of spirit,

singe over straw, first allowing the smoke to be consumed, and then holding the bird over it, turning it round about until it is perfectly singed. Singeing with paper always blackens the skin. Rub the bird down with a dry cloth or a bunch of wing feathers to remove the effects of singeing.

Have a sharp pointed trussing-knife, and a dry dishcloth for wiping board and fingers during the process.

(1) Lay the fowl on its back. Remove the toes at the top joints, or else remove the whole of the foot and half of the shank, but never cut away the shank altogether at the hock joint.

(2) Trim the wing by cutting away end joint or extreme tip, the small digit, and the loose skin which holds the quill feathers. These parts are of no use in cooking.

(3) Place the bird on its breast, with the head lying away from the operator. Cut across the skin at the back of the neck $1\frac{1}{2}$ inches in front of the shoulders. Cut the short length of skin backwards towards the shoulders. Cut through the neck at the joint nearest the shoulders or body of the bird. Remove it by pushing towards the head and cutting off the skin at the front, 3 inches from the shoulders.

(4) The crop is then removed by inserting the thumb of the right hand under it at the left shoulder of the bird, and loosening it round to the right shoulder, and cutting it out along with a piece of the windpipe well down into the orifice or opening where the neck was cut off.

(5) To loosen the lungs, place the bird on its back, insert the middle finger of the right hand into the opening where the neck was cut out, and pass it down either side of the backbone. The lungs are raised from the ribs, and any loose tissue that comes in the way is

loosened. By loosening the lungs the entrails can be removed more readily afterwards.

The lungs are light reddish-coloured bodies, and when seen afterwards show the marks of the ribs, to which they adhere very closely.

(6) Set the bird on its front part and make a cut across between the tail and vent. Then hold the vent with the left hand, insert the point of the knife into the body, and cut round the vent and main intestine, taking care not to cut into the latter.

(7) The bird is then laid on its back. A finger of the right hand is turned round between the gizzard and lining of fat if a good chicken, and between gizzard and tissue if a lean one, in order to loosen the gizzard.

Then the gizzard is caught by the two first fingers and gently pulled towards the opening at the vent. All the entrails will come out attached to it, if the lungs have been loosened properly.

When everything comes out attached it is not necessary to wash out the bird, but simply to wipe it out with a dry dishcloth. To use water or even a damp cloth will spoil the keeping qualities of the bird.

The bird is now ready for trussing.

To Truss for Roasting.

(8) First of all close the front opening by folding the flap of skin at the back over the end of the neck, and afterwards turning back the front skin.

The wings are then doubled back to hold the skin in position, entirely closing the front part of the bird.

(9) Have a 10-inch trussing needle threaded with fine string. Place the bird on its back, with the forequarters

towards the left hand. With the left hand take hold of the two legs, and push them towards the fore-quarters. Pass the needle through the body behind the legs low down in the side of the bird, where there is an air cavity. Pull it out at the other side of the bird.

Turn the bird partly round. Pass the needle through the wing at the outside of the elbow, coming out through the end joint of the wing. Take the string across the back of the bird, pass it through the end joint on the opposite wing, and out at the side of the elbow. Take out the needle and tie the string very firmly, to hold the wings in position.

(10) The needle is again threaded with string. The legs are held down, and the needle passed through the body at the end of the keel which it catches on its way through.

The legs will now be under the string. Turn over the bird, pass the needle through the air cavities by the side of the backbone a little above the tail. Then again through the front over the legs, and catch the keel on the way through. Remove the needle. Pull each end of the string, cross it behind the hock joints, pass it round the tail, pull firmly, and tie. Bring the hock joints and tail close together to close the opening which was made to draw out the entrails.

The bird is then finished and ready for cooking.

Preservation of Eggs.

Two methods are used for preserving eggs at this Department.

Method No. 1.

A solution composed of one part water-glass (silicate of soda) and twenty parts water (5 per cent.) is used.

Water that has been boiled and slightly cooled should be used. Add to it the water-glass, and when quite cool put it into a jar or other suitable vessel used for preservation.

Fresh eggs are added from time to time until the jar is filled; but be sure to have at least 2 inches of the solution covering the eggs, so that none will be exposed to the air.

Method No. 2.

Lime Water.—A good solution is made as follows:—

$2\frac{1}{4}$ lbs. lime shell.
6 oz. salt.
$\frac{1}{2}$ oz. cream of tartar.
3 gals. boiling water.

Pour the water over the lime and salt. Allow the solution to stand for a day or two, stirring it occasionally; add cream of tartar. Remove the clear liquid by straining through a muslin cloth. The sediment is of no use, and when the liquid is not strained it fills a portion of the preserving vessel.

Place the liquid in the preserving vessel, and put in fresh eggs from time to time. Have 2 inches liquid above eggs.

Eggs preserved in lime become rougher of the shell.

Eggs can be preserved for home consumption, or for sale for cooking purposes.

The following points are important to success in preservation:—

(1) Eggs keep better from hens that have no males running with them, because an infertile egg keeps longer.

(2) Eggs must be perfectly fresh.

(3) Eggs must be perfectly clean; filth of any kind adhering to the shell will taint the preserving medium.

(4) In placing eggs in the preservative, be careful not to crack the shells.

(5) Eggs must be kept in a cool room.

(6) Remove any eggs which may float at any time.

Marketing of Eggs.

All eggs produced in this country are consumed, by which is meant none are sold for manufacturing purposes. The value of eggs as food is gradually being recognised more and more. Few realise how quickly and how easily an egg deteriorates in flavour; that their shells are porous or full of small holes; and that they readily absorb odours if placed alongside any strong-smelling foods.

The nests in which the hens lay should be clean. They should be renewed with fresh material monthly. Eggs should be collected twice daily, and kept in clean baskets. The room in which they are being kept should be cool and dry.

Very badly soiled, small, extra large, and "found" nests of eggs should not be sold.

In supplying private customers or a select wholesale trade the eggs should be stamped with the name of the farm, also the date.

Eggs should never be held over on the chance of a rising market, and preserved eggs should not be mixed with new-laid eggs for the same reason. Infertile eggs or eggs produced from hens which have no male birds along with them keep much better.

Soiled eggs should be rubbed with a damp cloth, or washed carefully in tepid water and thoroughly dried. Soiled eggs spoil the appearance of clean eggs, and washed eggs will deteriorate more quickly.

A musty flavour will be produced by contact with damp packing material.

In Scotland eggs and poultry can be disposed of direct to the consumer by farmers and poultry-keepers resident near large centres. This method of disposal is of necessity limited. In this way the best prices are obtained. They are, however, most often disposed of to the retailer, and little, if any, attempt is made at grading, the retailer paying a much reduced price for eggs under 2 oz.

Something is being done to assist the poultry-keepers in

outlying districts by the Scottish Agricultural Organisation Society, depôts being started for the collecting and marketing of the produce at enhanced prices, compared with the price obtained from local grocers. Formerly they had them at whatever price they liked to give, in exchange for goods.

No doubt, as the poultry-keepers of the country become more enlightened in method of production and management the marketing will also improve. It is important that produce should be sold to the public in as an attractive manner as possible.

Bulletin No. 65.

The West of Scotland Agricultural College.

REPORT

ON

THE RESULTS OF SOME EXPERIMENTS WITH FARMYARD MANURE.

BY

R. A. BERRY, F.I.C.,

Professor of Agricultural Chemistry.

GLASGOW, 1914.

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A REPORT ON THE RESULTS OF SOME EXPERIMENTS WITH FARMYARD MANURE.

By R. A. BERRY, F.I.C.,

Professor of Agricultural Chemistry.

The experiments described in this report were carried out at the College Experiment Station, Kilmarnock, and on farms situated in the West of Scotland. The experiments extend over a number of years, and some points are still under investigation. The present report deals with the results so far obtained.

In the West of Scotland the conditions, under which farmyard manure is made and used, present certain points of interest and of special importance. So far the existing data on the losses of the manurial ingredients in farmyard manure during storage have been derived largely from experiments carried out in comparatively dry climates, with a rainfall rarely exceeding 30 inches per annum. The rainfall in the West of Scotland is generally much above this figure.* In the administrative area under the College the mean annual rainfall is seldom below 35 inches per annum, which is the average rainfall registered for the low-lying land bordering the Ayrshire coast and the south-west coast of Wigtownshire. In the greater part of the southern and south-western counties the annual rainfall is between 40-50 inches, except in the higher and more exposed areas in the neighbourhood of the Lochs Doon, Dee, and Trool, where the annual rainfall is often as high as 80 inches per annum. In the western portions of Renfrewshire, Dunbartonshire, and Stirlingshire, in Argyll-

* The distribution of the rainfall over Scotland is dealt with in a paper on the mean annual rainfall of Scotland, 1871-1910, by the Secretary of the Meteorological Society, Edinburgh, and published in the *Journal* of that Society for 1910.

shire and in the adjacent islands, the average rainfall is between 60-80 inches, and in the higher and more exposed areas it frequently exceeds 100 inches per annum. In the central and eastern portions of the first three counties the rainfall registered is between 40-60 inches per annum.

It follows then, that where the bulk of the manure is stored in exposed heaps during the winter months in a wet climate, such as usually prevails in the West of Scotland, the losses of soluble manurial constituents by drainage from the manure heap must be considerably greater than in a drier climate.

Again, cow manure forms a big proportion of the manure made in the West of Scotland, and the food rations from which it is made are subject to considerable variation. For example, the daily allowance of roots per cow per day may run from 30 or 40 lbs. up to 100 lbs. or more. On the other hand, in many cases no roots are included in the rations. Likewise the quantity and the kind of dry foods fed vary considerably. The large amount of water supplied by the heavy root rations, or by rations containing large quantities of other succulent foods, will affect the quantity and concentration of the urine, and in all probability increase the losses due to drainage.* Further, the condition of the manure as regards its relative wetness or dryness will also be affected by the feeding, and this condition may subsequently influence the nature and the rate of fermentation in the manure.

Again, we must remember that the soils in the West of Scotland are generally poor in lime, and their mean summer temperature somewhat lower than that prevailing on the average in Great Britain. These peculiarities of soil and climate may possibly exercise some active influence not only on the vigour, but also on the types of bacterial flora of the soil, and therefore on the decay and rate of exhaustion of the manure in the soil, and consequently on the crop yields.

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* "Heavy Root Feeding and the Dungheap," by James Hendrick, B.Sc., F.I.C. *Transactions of the Highland and Agricultural Society*, Vol. XXIII., 1911.

STORAGE UNDER COVER AND IN THE FIELD.

This test was carried out at the College Experiment Station, Kilmarnock. About 16 tons of fresh cow manure, made with straw litter, were used in this experiment. The manure was made into two well-trodden heaps, one in the field, the other in a covered shed with a cement floor, and stored in each case from the 25th November, 1905, to the 4th April, 1906. The manure was weighed and sampled for analysis both before and after storage.

The percentage loss in weight of the two heaps during storage was, in two experiments—

	No. 1.	No. 2.	Mean.
Under cover, ...	17·0	18·0	17·5 per cent.
In the field, ...	19·7	21·5	20·6 ,,

The loss in weight of the manure is the result of a complicated series of destructive changes which the constituents of the manure undergo in the process of rotting. The nature of these changes, which are the work mainly of bacteria, enzymes, and moulds, will become apparent in the course of this report.

Sampling of the Manure for Analysis.—The method adopted was to cut out with a hay knife cores from four different parts of the heap. The total weight of the cores amounted to about two hundredweights. These were mixed as expeditiously and as thoroughly as possible, and from the mixture a sample sufficient to fill a bucket was taken. The rejected portions were put back again into the holes. The samples in the buckets were compressed, lids attached, and the buckets at once despatched to the chemical laboratory. There the contents were emptied into a zinc bath, cut into small pieces with shears, and portions, after well teasing out and mixing, were used for the different chemical determinations.

The chemical examination included a determination of the dry matter, nitrogen in different forms, total and water soluble phosphates and potash, ash and organic matter.

Notwithstanding the care taken in the sampling of the manure, the writer is fully aware of the difficulty in obtaining a representative sample. In order to ascertain the extent of the errors from this cause, duplicate samples in another experiment were taken and analysed separately. The results of the two analyses are given below :—

PERCENTAGE COMPOSITION.

	Sample 1.	Sample 2.	Mean.	Probable Error of Mean. Percentage.
Dry Matter, - -	21·47	21·63	21·55	± ·37
Nitrogen, - Total,	0·404	0·415	0·409	± 1·34
,, Ammoniacal,	0·128	0·127	0·127	± ·39
Phosphoric Acid, P_2O_5,	0·263	0·265	0·264	± ·38
Potash, K_2O, - -	0·517	0·526	0·521	± ·86
Ash, - - - -	5·02	5·09	5·055	± ·69

Table I. shows—

1. The composition of the fresh manure;

2. The composition of the manure rotted (*a*) in the open, (*b*) under cover; and

3. The losses of manurial constituents sustained during rotting.

TABLE I.

	Percentage Composition.			Percentage Loss of Manurial Constituents on Rotting.	
	Fresh.	Rotted.			
		In Open.	Under Cover.	In Open.	Under Cover.
Nitrogen, Total, - -	·421	·375	·406	28·4	19·9
,, Insoluble, -	·309	·297	·314	22·9	15·7
,, Soluble Protein,	·024	·009	·024	70·0	17·0
,, Ammoniacal, -	·076	·021	·023	77·8	74·7
,, Amide and Nitrate, -	·012	·048	·045	G	G
Phosphoric Acid, P_2O_5, Total,	·229	·225	·259	21·1	6·2
,, ,, P_2O_5, Soluble,	·096	·093	·124	22·2	7·2G
Potash, K_2O, Total,	·421	·376	·492	28·3	3·0
,, ,, Soluble,	·320	·272	·352	31·7	8·7
Dry Matter, - - -	19·96	19·15	21·4	22·9	11·0
Organic ,, - - -	14·44	14·26	14·94	20·7	14·2
Ash, - - - -	5·52	4·89	6·46	28·7	2·9

G = gain.

As would be expected, this table shows that the loss of manurial constituents from the exposed heap is greater than from the sheltered heap.

To consider these losses in more detail :—

Total nitrogen. — In the sheltered heap the loss of the total nitrogen originally present in the fresh manure amounted to 20 per cent., and in the exposed heap to 28 per cent.—a reduction of the loss by 8 per cent. in favour of the manure stored under cover.

Ammoniacal nitrogen is the most valuable form of nitrogen in the manure. The principal sources of loss of ammonium compounds from the manure are—

1. In solution in the drainage water either as ammonia or as ammonium salts;

2. The escape into the atmosphere of free ammonia, or of volatile ammonium salts, or of nitrogen formed by bacteria from ammonium compounds.

3. By temporary conversion of ammonium compounds, by bacteria, into more complex forms of nitrogen.

In both the sheltered and in the exposed heaps the loss of ammoniacal nitrogen was very great. In each case it amounted to over 70 per cent. of that originally present in the fresh manure. The percentage of ammoniacal nitrogen in the total nitrogen in the fresh manure was 18 per cent., and in the stored manures between 5 and 6 per cent. only. As the losses from the manure stored in the open, where there was unrestricted drainage, were only a little greater than from the manure stored under cover, where there was practically no drainage, the principal losses of ammonium compounds must have been due to causes other than drainage.

Amido- and Amino-Nitrogen.—These are the forms in which the digested nitrogen compounds of the food are excreted in the urine from the body. They are also produced in the manure heap as a result of the action of enzymes and bacteria upon proteins. The nitrogen in these forms is readily converted into ammonia.

The mineral substances—Phosphates and Potash Salts.—The losses here were due entirely to drainage. In the exposed heap there was a loss of 21 per cent. of phosphoric acid (P_2O_5), and of 28 per cent. of the potash (K_2O). Practically no loss of phosphoric acid or potash occurred in the sheltered heap after allowing for that due to experimental errors. The fresh

manure contained 42 per cent. of its total phosphoric acid, and 76 per cent. of its total potash soluble in water. This high proportion of soluble phosphates and potash salts makes it possible for the losses by drainage of these substances to be great. (See also experiment, page 189.)

The ratio of nitrogen to phosphoric acid in the fresh and rotted manure has been used in some cases, where the manure was not weighed, as a basis for the calculation of the loss of nitrogen during storage. It is clearly shown by the results of this experiment (see also experiment, page 189) that this basis of calculation, unless the manure is stored under conditions where no loss by drainage can occur, is not reliable.

Organic matter, or loss on ignition.—The loss of organic matter was 20·7 per cent. in the exposed heap, and 14 per cent. in the sheltered heap. The loss is due to bacterial and chemical action, and to a smaller extent to drainage. The dark brown-coloured liquid draining from a manure heap owes its colour to the presence of soluble organic matter. The loss due to bacterial action is caused mainly by the conversion of combined carbon into carbon dioxide gas or into methane, and of combined hydrogen into water or into free hydrogen.

The proportion of the different forms of nitrogen to the total nitrogen, and also of the soluble phosporic acid and potash to the total phosporic acid and potash in the manure, is given in Table II., page 184.

TABLE II.

The total Nitrogen, total Phosphoric Acid, and total Potash is in each case taken as 100.

	Percentage of Total		
	Fresh.	Rotted.	
		In Open.	Under Cover.
Nitrogen,			
,, Insoluble,	73·4	79·2	77·3
,, Soluble Protein,	5·7	2·4	5·9
,, Ammoniacal,	18·0	5·6	5·7
,, Amide and Nitrate,	2·9	12·8	11·1
Phosphoric Acid, P_2O_5,			
,, ,, Soluble,	41·9	41·3	47·9
Potash, K_2O,			
,, Soluble,	76·0	72·3	71·5

The above figures are interesting, in so far as they show the effect of storage on the relative proportions, of the different forms of nitrogen compounds, of phosphoric acid, and of potash, in the manure.

After storage the manure was applied to a potato and also to a turnip crop, in each case at the rate of 20 tons per acre. The size of the plots was $\frac{1}{40}$th of an acre, and each plot at each experiment was quadrupled.

The weights in lbs. per acre of manurial constituents supplied in the two dressings are given in Table III., page 185.

TABLE III.

Manurial Constituents.	Contained in 20 tons Farm-yard Manure.		
	Rotted.		Fresh.
	Under Cover.	In the Field.	
	lbs.	lbs.	lbs.
Nitrogen, Total, - -	182	168	188
,, Soluble, -	41	35	50
Phosphoric Acid, P_2O_5, -	116	101	102
Potash, K_2O, - - -	220	168	188

The last column in the table shows the weight of manurial constituents in twenty tons of fresh manure for comparison with the amounts present in the rotted manures. These figures are given merely to emphasize the difference between the two dressings. They, however, only represent the approximate quantities of manurial ingredients supplied, because errors due to sampling and applying the manure make it impossible to calculate the actual quantities with any great degree of accuracy.

The crop returns per acre are given in Table IV.

TABLE IV.

Manuring per acre. 20 tons Dung.	Potatoes.	Turnips.
	Mean of eight plots.	Mean of eight plots.
	T. C. Q.	T. C. Q.
Rotted under Cover, - -	12 5 1	26 11 1
,, in the Field, - -	11 13 2	25 7 1
Average Increase in favour of Manure stored under Cover, - - - - -	0 11 3	1 4 0
*Value of Increase in favour of Manure stored under Cover, - - - - -	£1 5 5	£0 9 7
Increased Value per ton of Manure, - - -	1s. 3d.	5d.

* The potatoes were valued at 45s. and the turnips at 8s. per ton.

According to the previous table, the effect of storage under cover has increased the value of the manure over the manure stored in the open by 1s. 3d. per ton, valued according to the potato increase, and by about 5d. per ton, valued from the turnip increase.

Table V. gives the increases worked out in percentages.—If we take the yield of the unmanured plot as 100, and calculate the yields of the manured plots in terms of this, then we shall see whether the variation in yield is due to any difference in manurial value of the two kinds of rotted manure or to errors inevitable to field experiments.

TABLE V.

20 tons of Dung after Storing.	YIELD OF UNMANURED PLOT = 100.	
	Potatoes.*	Turnips.*
	Mean of 8 Plots.	Mean of 8 Plots.
Under Cover, - - - -	157	145
In Open, - - - - -	149	138
Increase in favour of Storage under Cover, - - - - -	8	7
Increase, average of 16 Plots, -	7 per cent.	

* See also Bulletin 38. "On the Results of a Rotation Experiment," by R. A Berry, F.I.C. *The West of Scotland Agricultural College.*

The increased yield of 7 per cent. in favour of the manure stored under cover is the average result of 16 plots, and it may be assumed with some degree of reliability that the increase is really due to a difference in manurial value of the stored manures, and not to experimental errors. The rainfall for the period is given in table, p. 251.

SUMMARY.

The loss in weight in fresh farmyard manure amounted, on an average, to 17·5 per cent. when stored under cover, and to 20·6 per cent. when stored in the open for a period of four months. The average rainfall was 39·32 inches per annum.

The fresh manure contained 73·4 per cent. of its total nitrogen in the form of compounds insoluble in water, 18 per cent. in the form of ammoniacal nitrogen, and the remainder, namely, 8·6 per cent., in the form of amide and soluble proteid nitrogen. Whilst 42 per cent. of its phosphoric acid and 76 per cent. of its potash was in the form of salts soluble in water.

The loss in manurial constituents was greatest in the manure stored in the open. In the case of total nitrogen the loss amounted to 28·4 per cent., which is 8 per cent. more than that sustained by the manure stored under cover. In the case of phosphoric acid the loss amounted to 21·1 per cent., and in the case of potash to 28·3 per cent., compared with practically no loss sustained by the manure stored under cover.

Owing to the large loss of nitrogen during storage, both rotted manures were left poorer in total nitrogen, and also in the more available forms of nitrogen than the fresh manure. The manure stored in the open suffered most in this respect.

The ammoniacal nitrogen formed the principal source of loss of nitrogen in the manure. Of the losses in the different compounds of nitrogen the loss of ammoniacal compounds was the greatest, and amounted to between 70 and 80 per cent. of that originally present in the fresh manure. The insoluble nitrogen and the soluble protein nitrogen compounds also sustained serious losses.

The slight increase in the amide nitrogen in the rotted manures, considered along with a similar increase in the insoluble nitrogen, and the much larger decrease in the ammoniacal nitrogen in the rotted compared with the fresh

manures is interesting as throwing some light on the change in the compounds of nitrogen during storage.

Drainage accounted entirely for the loss of mineral substances (phosphoric acid and potash), as there was practically no loss of these substances in the manure where there was no drainage. It also accounted for some loss of soluble proteid nitrogen and of ammoniacal nitrogen, but as the loss of the latter substance was much the same in the two rotted manures it is plain that the main cause of the loss of ammonia and its compounds must be due to causes other than drainage.

Comparing the two methods of rotting the fresh manure it is clear that the advantage of rotting the manure under cover over that of rotting in the open is mainly to avoid the rather serious losses, of mineral substances and, to a smaller extent, of the compounds of nitrogen which occur when the manure is stored in the open without any protection against rain and drainage. The result is that the manure which has been stored under cover is the more valuable manure.

The average percentage increase of crop in favour of storing the manure under cover over the increase produced by the manure stored in the open is 7 per cent..

The errors due to sampling of the manure for analysis were such as not to interfere with the main results of the experiments.

THE STORAGE OF DIFFERENT KINDS OF FRESH MANURE IN EXPOSED HEAPS IN THE FIELD.

The following manures were employed for this test, namely, cow, bullock, pig, and horse manure. The pig and cow manures were obtained from Holmes Farm, and the others were purchased locally. Straw was used as litter in all cases except one, when peat moss was employed. In appearance the pig and cow manures were the wetter, and the bullock and horse the drier of the manures.

The experiment was started on December 18th, 1908, when the manures were stored in well trampled heaps, each containing between four and five tons of dung. Each heap was sampled for analysis as indicated on page 179, and stored without any covering until the 22nd of April following, when each heap was again sampled and weighed.

The percentage loss in weight sustained by the fresh manures during storage was—

Horse, with moss litter, - - -	12·6 per cent.
Cow, ,, straw ,, - - -	14·9 ,,
Pig, ,, ,, ,, - - -	26·5 ,,
Bullock, ,, ,, ,, - - -	28·3 ,,
Horse, ,, ,, ,, - - -	29·0 ,,
Average loss, - - -	22·3 ,,

With larger heaps the losses would in all probability have been smaller. In the case of the horse manure, when moss litter was substituted for straw litter, the total loss was considerably reduced.

The composition of the fresh and rotted manures is given in Table VI., page 190.

TABLE VI.

FRESH AND ROTTED MANURES—PERCENTAGE COMPOSITION.

	Cow.		Bullock.		Horse, Moss Litter.		Horse, Wheat Straw Litter.		Pig.	
	Fresh.	Rotted.	Fresh.	Rotted.	Fresh.	Rotted.	Fresh.	Rotted.	Fresh.	Rotted.
Nitrogen, Total,	·354	·359	·663	·518	·428	·301	·342	·346	·407	·427
,, Insoluble,	·241	·238	·482	·452	·320	·245	·258	·318	·282	·354
,, Soluble Protein,	·013	·026	·053	·027	·006	·017	·017	·0175	·020	·008
,, Ammoniacal,	·074	·064	·070	·003	·082	·006	·045	·003	·055	·008
,, Amide and Nitrate,	·026	·031	·058	·036	·020	·033	·022	·0075	·050	·057
Phosphoric Acid, P_2O_5, Total,	·192	·219	·374	·369	·193	·178	·203	·274	·395	·505
,, ,, Soluble,	·101	·109	·226	·18	·131	·123	·103	·067	·128	·149
Potash, K_2O, Total,	·296	·246	·823	·546	·337	·279	·271	·311	·446	·363
,, Soluble,	·232	·174	·625	·447	271	·189	·213	·249	·307	·207
Dry Matter,	18·3	19·2	28·23	21·13	21·73	18·46	22·75	19·43	21·43	22·36
Organic Matter,	13·03	14·13	22·66	15·21	17·32	15·13	16·74	13·45	13·15	11·87
Ash,	5·265	5·07	5·57	5·92	4·41	3·33	6·01	5·98	8·28	10·49

The composition of the different kinds of manure will of course depend mainly upon the composition of the food consumed, and upon the age and kind of animal consuming the food. The richer the food is in compounds of nitrogen, the richer will be the manure in these substances. In the case of grain, oil cakes, and concentrated foods generally, between 70 and 90 per cent. of the total nitrogen present in the food is digestible, but with coarse fodders the amount digested is much lower.

A certain proportion of the digestible nutrients is retained by the body for sustenance. The digested nitrogen retained for body requirements by fattening cattle, fattening sheep and by horses at work is about 5 per cent., by fattening pigs about 15 per cent., by cows in milk about 25 per cent., and by young stock a still higher percentage, of the total nitrogen assimilated from the food. The remainder, that is the bulk of the digested nitrogen, passes out in solution in the urine. The greater part of the soluble potash salts of the food is also excreted in the urine. Whilst the bulk of the phosphoric acid appears in the dung.

In Table VII., page 192, the fresh manures are arranged in order of their percentage of total nitrogen.

TABLE VII.

FRESH MANURES, PERCENTAGE COMPOSITION.

	Horse, Straw Litter.	Cow.	Pig.	Horse, Moss Litter.	Bullock.	Average.
Nitrogen, Total, - -	·342	·354	·407	·428	·663	·439
,, Insoluble, - -	·258	·241	·282	·320	·482	·317
,, Soluble Protein,	·017	·013	·020	·006	·053	·022
,, Ammoniacal, -	·045	·074	·055	·082	·070	·065
,, Amide & Nitrate,	·022	·026	·050	·020	·058	·035
Phosphoric Acid, P_2O_5, Total,	·203	·192	·395	·193	·374	·271
,, ,, P_2O_5 Soluble,	·103	·101	·128	·131	·226	·138
Potash, K_2O, Total, -	·271	·296	·446	·337	·823	·435
,, ,, Soluble, -	·213	·232	·307	·271	·625	·330
Dry Matter, - - - -	22·75	18·3	21·43	21·73	28·23	22·49
Organic Matter, - -	16 74	13·03	13·15	17·32	22·66	16·58
Ash, - - - - -	6·01	5·27	8·28	4·41	5·57	5·91

The manures from bullocks, and from horses with moss litter are the richest in total nitrogen. They will contain a larger proportion of absorbed urine, which will account to some extent for their richness in compounds of nitrogen. The manure from pigs, or from cows, or from horses with straw litter will contain less absorbed urine. The difference in absorbing properties of moss and straw litter respectively is well demonstrated in the experiment with the two horse manures. The straw litter manure contained ·342 percentage of nitrogen, and the moss litter manure ·428 per cent. It must be remembered, however, that moss litter is richer in nitrogen than straw litter, which will to a certain extent account for the difference in total nitrogen in the two manures.

The composition of the rotted manures is given in Table VIII. The manures are arranged in order of their percentage of total nitrogen.

TABLE VIII.

ROTTED MANURES, PERCENTAGE COMPOSITION.

	Horse, Moss Litter.	Horse, Straw Litter.	Cow.	Pig.	Bullock.	Average.
Nitrogen, Total, - -	·301	·347	·359	·427	·518	·390
,, Insoluble, -	·245	·318	·238	·354	·452	·321
,, Soluble Protein,	·017	·0175	·026	·008	·027	·019
,, Ammoniacal, -	·006	·003	·064	·008	·003	·017
,, Amide & Nitrate,	·033	·0075	·031	·057	·036	·033
Phosphoric Acid, P_2O_5, Total,	·178	·274	·219	·505	·369	·309
,, ,, P_2O_5, Soluble,	·123	·067	·109	·149	·180	·126
Potash, K_2O, Total, -	·279	·311	·245	·363	·546	·349
,, Soluble, -	·189	·249	·174	·207	·447	·253
Dry Matter, - - -	18·46	19·43	19·2	22·36	21·13	20·11
Organic Matter, - -	15·13	13·45	14·13	11·87	15·21	13·96
Ash, - - - - -	3·33	5·98	5·07	10·49	5·92	6·16

On comparing the composition of the different fresh and rotted manures, it will be seen that the manures, after storage, from cows, pigs, and horses where straw litter was used show an increased percentage of nitrogen. In other words, the losses and shrinkage of the fresh manure in the process of rotting has fallen in greater proportion on the substances which contain no nitrogen; the result has been a slight concentration of nitrogen in the rotted manure. The manures from bullocks, and from horses with moss litter, are poorer in nitrogen after rotting. These two manures in the fresh state are the richest in nitrogen, and the readily fermentable

nitrogen compounds of the urine. It is, therefore, important to note that the richer the fresh manure is in nitrogen compounds the greater proportionately will be the losses of these compounds during storage.*

The effect of storage on the percentage of ammoniacal nitrogen was very pronounced. In all cases, except in the cow manure, there was a remarkable decrease in the percentage of this constituent in the rotted compared with that in the fresh manure. The same remark applies to the organic matter in the rotted compared with that in the fresh manures.

The losses of manurial constituents sustained by the different manures during rotting is given in Table IX.

TABLE IX.

THE PERCENTAGE LOSSES OF MANURIAL CONSTITUENTS SUSTAINED BY THE DIFFERENT MANURES IN ROTTING.

	Cow.	Pig.	Horse, Straw Litter.	Horse, Moss Litter.	Bullock	Average Loss.
Nitrogen, Total, - - -	13·8	23·0	28·3	38·7	44·0	29·6
,, Insoluble, - -	15·9	7·7	12·5	33·0	32·8	20·4
,, Soluble Protein, -	70·4G	70·5	26·5	150·0G	64·1	11·9G
,, Ammoniacal, - -	26·8	89·4	96·3	93·6	97·1	80·6
Phosphoric Acid, P_2O_5, Total,	2·8	6·1	4·1	19·1	28·9	12·2
,, Soluble,	8·0	14·2	53·6	12·5	42·6	26·2
Potash, K_2O, Total, - -	29·2	40·2	18·4	27·6	52·2	33·5
,, Soluble, - -	36·1	50·5	17·0	39·0	48·5	38·2
Dry Matter, . - - -	10·6	23·3	39·5	25·8	46·3	29·1
Organic Matter, - - -	7·7	33·7	42·9	23·7	51·9	32·0
Ash, - . - - -	17·9	6·9	29·5	34·0	23·7	22·4

G = gain.

* See also "Losses in Making and Storing Farmyard Manure," by Prof. T. B. Wood, M.A. *The Journal of Agricultural Science.* Vol. II., Part 2.

The main features of the table may be stated as follows :—

Total Nitrogen.—The average loss for the five manures was 29·6 per cent., and, as already indicated, the greater loss occurred in the richer manures. *Ammoniacal Nitrogen.*—The average loss amounted to 80 per cent. of that originally present in the manure. *Mineral Substances.*—The losses vary considerably in the different manures—the average loss of phosphoric acid was 12 per cent., and of potash 33·5 per cent. *Organic Matter.*—Here also the losses were very variable, and on an average amounted to 32 per cent.

It should be noted that the losses of nitrogen were the least in the cow manure, and that the losses from the horse manure with peat moss were almost the greatest.

The results, although only applicable to the present experiment, are, nevertheless, most instructive in that they show how the prevailing conditions affect the losses during storage, yet under altered conditions quite different results might be obtained.

The percentage of the different forms of nitrogen in the total nitrogen, soluble phosphoric acid, and soluble potash in the total phosphoric acid and potash in the manures is given in Table X., page 196.

TABLE X.

The total Nitrogen, total Phosphoric Acid, and total Potash is in each case taken as 100.

	Cow.		Bullock.		Horse, Moss Litter.		Horse, Straw Litter.		Pig.		Average.	
	Fresh.	Rotted.	Fresh.	Rotted.	Fresh.	Rotted.	Fresh.	Rotted.	Fresh.	Rotted	Fresh.	Rotted.
Nitrogen, Insoluble, -	67·5	66·3	72·7	87·2	74·8	81·4	75 4	92·0	69·3	82·9	71·9	81·9
,, Soluble Protein,	3·6	7·2	8·0	5·2	1·4	5·6	5·0	5·1	4·9	1·9	4·6	5·0
,, Ammoniacal, -	20·7	17·8	10·6	0·6	19·2	2·0	13·2	0·8	13·5	1·9	15·4	4·6
,, Amide & Nitrate,	8·2	8·7	8·7	7·0	4·6	11·0	6·4	2·1	12·3	13 3	8·1	8·5
Phosphoric Acid, P_2O_5, Soluble, - - -	52·6	49·7	60·4	48·8	67·6	68·9	50·7	24·5	32·4	29·5	52·7	44·3
Potash, K_2O, Soluble, -	78·4	70·7	75·9	81·9	80·4	67·7	78·6	80·2	68·8	57·0	76·4	71·5

From this table it appears that the net result of rotting has been to increase the proportion of insoluble nitrogen compounds, to reduce the proportion of ammoniacal compounds, of soluble phosphoric acid, and of soluble potash in the rotted compared with that in the fresh manures. In other words, the rotted manures contain a lower proportion of readily available manurial constituents than the fresh manures from which they were made. This result is also substantiated by the results of field trials (see p. 199).

For comparison, the figures for the fresh manures from Table X. have been tabulated in Table XI., and the figures for the rotted manures have been tabulated in Table XII.

TABLE XI.

FRESH MANURES.—PERCENTAGE COMPOSITION.

The total Nitrogen, total Phosphoric Acid, and total Potash is in each case taken as 100.

	Cow.	Pig.	Bullock	Horse, Moss Litter.	Horse, Straw Litter.	Average
Nitrogen, Insoluble, - -	67·5	69·3	72·7	74·8	75·4	71·9
,, Soluble Protein, -	3·6	4·9	8·0	1·4	5·0	4·6
,, Ammoniacal, - -	20·7	13·5	10·6	19·2	13·2	15·4
,, Amide and Nitrate,	8·2	12·3	8·7	4·6	6·4	8·1
Phosphoric Acid, P_2O_5, Soluble,	52 6	32·4	60·4	67·6	50·7	52·7
Potash, K_2O, Soluble, - -	78·4	68·8	75·9	80·4	78·6	76·4

TABLE XII.

ROTTED MANURES.—PERCENTAGE COMPOSITION.

The total Nitrogen, total Phosphoric Acid, and total Potash is in each case taken as 100.

	Cow.	Horse, Moss Litter.	Pig.	Bullock	Horse, Straw Litter.	Average
Nitrogen, Insoluble, - -	66·3	81·4	82·9	87·2	92·0	81·9
,, Soluble Protein, -	7·2	5·6	1·9	5·2	5·1	5·0
,, Ammoniacal, - -	17·8	2·0	1·9	0·6	0·8	4·6
,, Amide and Nitrate,	8·7	11·0	13·3	7·0	2·1	8·5
Phosphoric Acid, P_2O_5, Soluble,	49·7	68·9	29·5	48·8	24·5	44·3
Potash, K_2O, Soluble, - -	70·7	67·7	57·0	81·9	80·2	71·5

The rotted manures were applied in drills to a potato crop, at the rate of 20 tons per acre. The size of the plots was $\frac{1}{40}$th of an acre, and each plot was in duplicate.

The manurial constituents in lbs. supplied by 20 tons of the different rotted manures are shown in Table XIII. The manures are arranged in order of the weight of total nitrogen which they supply.

TABLE XIII.

	Supplied in 20 tons Rotted Manure.				
	Horse, Moss Litter.	Horse, Straw Litter.	Cow.	Pig	Bullock.
Nitrogen, Total, - -	134	155	161	191	232
,, Soluble, - -	25	12	54	33	30
Phosphoric Acid, P_2O_5, Total, - - -	79	123	98	226	164
Potash, K_2O, Total[1] -	125	139	110	162	244

The yield per acre of potatoes from the different plots is given in Table XIV.

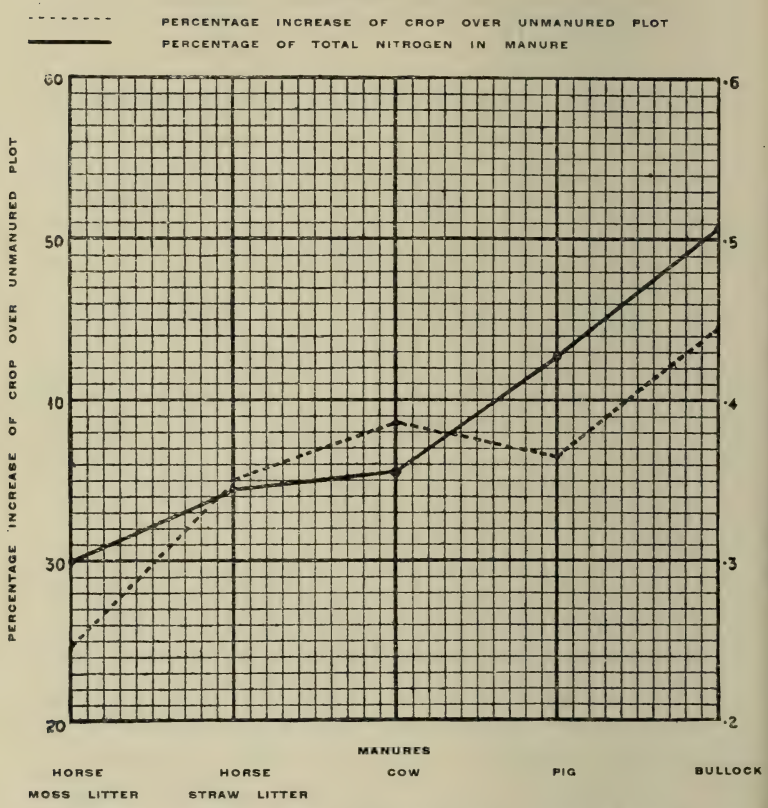
TABLE XIV.

20 tons Rotted Manure per Acre.	Potatoes Yield per Acre.			Potatoes, increase over Unmanured Plot.			Potatoes, percentage increase over Unmanured Plot.
	Tons.	Cwts.	Qrs.	Tons.	Cwts.	Qrs.	
Horse, Moss Litter. -	10	16	0	2	3	1	24·9
Horse, Straw Litter, -	11	3	1	3	0	1	34·8
Cow, - - - -	11	19	2	3	6	3	38·6
Pig, - - - -	11	16	0	3	3	1	36·6
Bullock, - - -	12	9	2	3	16	3	44·4
Unmanured, - -	8	12	3		—		—

The results are in each case the average of two plots. The manures are arranged in the same order as in Table XIII., that is, according to the weight of total nitrogen which they supply. The horse manure (moss litter) gave the lowest, and the bullock manure the highest yield of potatoes. The difference between the highest and the lowest yield of potatoes was 1 ton 13 cwts. It was intended to determine the manurial residues of the different manures, but the crop used for the purpose, namely wheat, failed, and the Italian rye grass which was afterwards sown was not satisfactory.

The diagram on page 200 shows the weight of nitrogen supplied in the different manures and the percentage increase of crop produced :—

DIAGRAM No. I.



As seen in the above diagram, the curve showing the increased weight of potatoes from the plots with the different manures follows very closely that showing the supply of nitrogen in the manure. This experiment, therefore, shows that the chemical composition of a manure is a good guide to its manurial value.

At the Experiment Station the effect of the addition of organic matter in the manures to the soil is not so important as on many other soils where this substance exercises a dominating influence on soil fertility. The soil is a medium loam, already well supplied with organic matter, in good mechanical condition, with a gravelly subsoil, and a water level about 40 inches below the surface, and, moreover, the average rainfall is about 40 inches per annum.

The analysis of the soil and of the subsoil is given in Table XV. following :—

TABLE XV.

Chemical Analysis. Percentage in Air-dry Sample.	Soil.	Subsoil.	Mechanical Analysis. Percentage in Air-dry Sample.	Soil.	Subsoil.
Moisture, - - -	5·0	4·6	Fine Gravel, above 1 mm., -	8·0	9·1
Loss on Ignition, -	13·4	10·1	Coarse Sand, 1 to 0·2 mm., -	20·6	22·8
Nitrogen, - - -	0·38	0·24	Fine Sand, 0·2 to 0·04 mm.,	24·1	24·3
Phosphoric Acid, P_2O_5, Total, - - -	0·23	0·20	Silt, 0·04 to 0·01 mm.,	12·5	17·0
Phosphoric Acid, P_2O_5, Available, - -	0·025	0·016	Fine Silt, 0·01 to 0·002 mm.	11·3	5·3
Potash, K_2O Total, -	0·26	0·24	Clay, below 0·002 mm.	4·8	6·1
,, ,, Available,	0·011	0·009	Moisture, - - - -	5·0	4·6
Lime, CaO, Total, -	1·4	0·4	Loss on Ignition, - . -	13·4	10·1
Calcium Carbonate, -	0·22	0·10	Calcium Carbonate, - -	0·2	·1
			Total, - - - -	99·9	99·4
			Stones, above 3 mm., -	19·8	30·5

The above analysis shows the soil to be in a good state of fertility, though the percentage of available potash and of carbonate of lime is low. The larger-sized particles predominate, and had it not been for the abundant water supply in the subsoil, the soil would dry readily, and crops would undoubtedly suffer in periods of drought.

We have seen that large losses in manurial constituents occur in the storage of the manure during the winter, and also that the crop returns from the different manures depend upon the chemical composition of the manure. It is, therefore, a question of practical importance to decide which is the better course to follow under a given set of conditions—to rot the manure in heaps and apply the rotted manure to

the land in the spring, or to apply the fresh manure to the stubble in the autumn and plough it in in preparation for the crop to be sown in the following spring. (See experiment, page 219.)

SUMMARY.

The average loss in weight of five different kinds of manures when stored in the open from the end of November to the end of March was 22·3 per cent. The loss was considerably reduced when peat moss litter was used in place of straw litter.

Of the fresh manures, that from fattening bullocks and from horses with peat moss litter were richest in soluble and available compounds of nitrogen, in phosphoric acid, and in potash soluble in water. Next in order were the manures from cows, pigs, and from horses with straw litter. The former two manures would contain more absorbed urine than the three latter.

By using peat moss litter in place of straw litter a larger proportion of urine is absorbed and the fresh manure thereby increases in value, as shown by a comparison of the composition of the two horse manures where peat moss and straw litter were respectively used; the former contains a larger proportion of available manurial constituents.

A comparison of the composition of the fresh and rotted manures shows that the two fresh manures richest in compounds of nitrogen are left poorer in these compounds after rotting, whilst the fresh manures relatively poorer in compounds of nitrogen are left slightly richer in total nitrogen after rotting.

The average loss of manurial constituents in the five manures during rotting was :—Total nitrogen, 29·6 per cent.; total phosphoric acid, 12·2 per cent; total potash, 33·5 per cent.; and organic matter, 32 per cent. Here, as in the previous experiment, the main source of loss of nitrogen was in the form of ammonia.

The losses of nitrogen were greatest in the fresh manures richest in compounds of nitrogen, hence it follows that, if one

of the objects of heavy cake feeding is to enrich the manure, especially in nitrogen, the practice is not an economical one if the manure is to be stored some time before its use. Although peat moss litter is of great advantage in retaining urine, it does not protect the manure, during storage, from greater losses consequent upon its enriched state.

The average effect of rotting has been without exception to lower the value of the manure for manurial purposes, if the value of the manure depends upon its power of supplying available manurial constituents. For example, the rotted manures contain in the total nitrogen on an average 4 per cent. of ammoniacal nitrogen and 82 per cent. insoluble compounds, compared with 15 and 72 in the fresh; also the rotted manure contains 44 per cent. of its phosphoric acid and 71 per cent. of its potash soluble in water, compared with 53 and 76 in the fresh.

When equal weights of the rotted manures were applied to a potato and to a turnip crop the increased yield of crop correspond very closely with the supply of the soluble and active compounds of nitrogen in the manure as determined by chemical analysis.

Where farmyard manure is used on soils of average fertility the chemical analysis of the manure, showing the percentage of the different forms of nitrogen, also of the phosphoric acid and potash soluble in water, is the best guide to its manurial value.

COMPOSITION OF COW MANURES.

To show the amount of variation in composition met with in practice, the analyses of twelve samples of cow manure are given in Table XVI., on opposite page. The analyses were made in connection with a rotation experiment, and they are representative of manure made at twelve typical dairy farms in the West of Scotland. The manures are numbered and arranged in the table in ascending order of the percentage of total nitrogen.

The richness of the manures in nitrogen will of course depend largely on the richness of the food consumed in nitrogen compounds. The percentage of total nitrogen in the manures varies from ·237 in the lowest to ·462 in the highest. The variation in the percentage of the mineral ingredients, particularly of phosphoric acid, follows fairly closely that of the nitrogen variation. This would be accounted for by the fact that the cake and grains which would supply part of the nitrogen are also rich in phosphates.

TABLE XVI.

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	Average.
Dry Matter, - -	17·5	20·6	18·6	19·4	18.5	17·7	22·8	19·4	22·4	19·6	22·6	20·3	19·95
Nitrogen, Total, - -	·237	·278	·288	·304	·335	·341	·359	·360	·394	·402	·409	·462	0·346
,, Ammoniacal,	·024	·059	·052	·085	·082	·034	·035	·076	·129	·060	·058	·051	0·064
Phosphoric Acid, P_2O_5, Total, - - - -	·199	·170	·180	·253	·247	·273	·285	·225	·264	·428	·296	·376	0·266
Potash, K_2O, Total, -	·347	·263	·344	·324	·359	·422	·322	·430	·386	·417	·497	·458	0·381
Ash, - - - - -	3·91	3·92	2·50	3·90	2·950	4·08	7·39	3·83	4·59	4·35	4·37	5·49	4·27

THE TREATMENT OF FARMYARD MANURE DURING STORAGE.

The results of the two previous experiments show in what way and to what extent losses of manurial constituents may occur during the rotting of fresh manure. Drainage accounts for the loss of the soluble mineral substances, but it by no means accounts for all the loss of the compounds of nitrogen.

The question of the loss of the compounds of nitrogen may fortunately be studied from several points of view. It may be considered under two headings—Drainage and Fermentation. Under these two headings precautionary measures, taken with the object of controlling and minimising the losses, can be grouped as follows:—

Precautionary measures against undue losses of nitrogen by Drainage.

1. By the absorption and retention of as much of the urine as possible by employing suitable litter.
2. By collecting and preserving the unabsorbed urine in tanks.
3. By protecting the manure from rain and the leeching action of drainage water.

Precautionary measures against undue losses by Fermentation.

1. By checking fermentation in the manure heap by the addition of suitable antiseptics.
2. By restricting fermentation in the manure heap by the exclusion of air.
3. By the fixation of the free ammonia produced in the manure by the addition to the manure of substances suitable for this purpose.

Under drainage the methods applicable are fairly obvious,

and do not require any special comment or explanation, yet it may be advisable to draw attention to one or two points connected with the losses of nitrogen by drainage which might be overlooked.

In the preservation of the urine unabsorbed by the litter, the urine should be allowed to drain, with as little hindrance as possible, into the collecting tank. If the urine trickles slowly over an irregular and exposed surface, forming little puddles in its passage, no better conditions could be devised, not only for the bacterial production of ammonia, but also for the volatilisation of the ammonia produced.

When preserving the urine in tanks it is advisable to reduce to a minimum the evaporating surface of the liquid. This, of course, is best accomplished by roofing in the tank, and keeping the inlet and exit openings as small as possible. Unnecessary heating of the tank should also be avoided, for it must be remembered that moderate heat not only encourages bacterial activity, but also hastens evaporation, both of which should be kept in check. For this reason the tank should be built either in the ground, or in as cool a place as possible.

Afterwards, in the utilisation of the liquid for manurial purposes, care must be taken that the concentration of the ammonia in the urine is not too great, for a too concentrated solution has a toxic or poisonous action on plants. For this reason the urine should be diluted down with water before its application to a growing crop.

The present experiment was practically confined to a comparison of the methods available for restricting fermentation and for fixing the ammonia produced by fermentation in the manure. For this purpose antiseptics and other substances were employed. No originality is claimed for any of the tests, for similar experiments with the same object in view have been undertaken by other investigators, but many of the results obtained have been contradictory.

Fresh cow manure was employed for the experiment, and in order to have the manure as uniform as possible, cut straw was used as litter and the heap turned twice and thoroughly mixed before the commencement of the experiment.

The experiment started on February 11th, 1908, when equal weights of manure, amounting to 9 cwts. in each lot, were weighed from the heap on to a cement floor. There the manure was mixed as thoroughly as possible with the various preservatives to be used, then packed at once into boxes made of haskenized wood, and stored under cover until May 4th. Each test was carried out in duplicate. A thermometer encased in a glass tube was buried in the centre of the manure in each box, and the temperature read and recorded from time to time. The weight of each box was taken at the beginning and at the end of the experiment. All of the boxes lost weight during the storage.

Samples of manure were also taken from each of the boxes for analysis, and the result of the analysis and a list of the substances used as preservatives are given in Table XVII., page 210.

The object of the different substances tried may be stated briefly as follows :—

Superphosphate of lime contains an acid salt of phosphoric acid. The acid salt combines with ammonia, fixing it in the form of a non-volatile ammonium salt. Other investigators have found that the presence of superphosphate in the manure sets up a condition in the manure which favours bacterial activity, and results, after the acid salt is neutralised, in increased losses of ammonia from the manure. The superphosphate was applied at the rate of 25 lbs. per ton of manure.

Kainit was added at the rate of 22·4 lbs. per ton of manure, equal to 1 per cent. of the manure. Interaction between the sulphates and chlorides contained in the kainit, and the ammonium carbonate in the manure takes place, whereby ammonium sulphate and ammonium chloride is formed. The action is a reversible one.

Gypsum reacts with the ammonium carbonate in the manure in the same way, ammonium sulphate and calcium carbonate

being formed. This action is reversible, and a relatively large excess of gypsum requires to be used for the change to go in the desired direction. The gypsum was applied at the rate of 44·8 lbs. per ton of manure, equal to 2 per cent. of the manure. In experiments where gypsum was employed there was found to be a certain amount of reduction of the calcium sulphate to calcium sulphide. The presence of the latter compound in the manure in any quantity is harmful because of its toxic action on plants.

Acid sodium sulphate acts in the same way as the acid salt in superphosphate of lime. It was applied at the rate of 11·2 lbs. per ton of manure, equal to ·5 per cent.

The antiseptics were added to check fermentation.

Table XVII., page 210, gives the kind and the amount of each of the substances used as preservatives, the analyses of the fresh manure and of the treated manure after storage.

TABLE XVII.—PERCENTAGE COMPOSITION.

Number of Experiment.	Quantity of Preservative or Antiseptic used.	Nitrogen.					Dry Matter.	Organic Matter.	Ash.
		Total.	Insoluble.	Soluble Protein.	Ammoniacal.	Amide and Nitrate.			
	Fresh Manure, Average, - - -	·323	·228	·027	·055	·013	18·13	14·95	3·18
	After Storage with—								
1	Superphosphate, ·25 per cent. Acid Salt	·327	·238	·016	·072	·001	19·48	15·03	3·35
2	Kainit, 1 ,,	·310	·234	·010	·064	·002	18·73	14·82	3·91
3	Gypsum, 2 ,,	·335	·252	·018	·062	·003	20·04	15·60	4·44
4	Sodium Acid Sulphate, ·5 per cent. -	·327	·236	·018	·068	·005	18·71	15·15	3·56
5	Carbonate of Lime, 5 ,, -	·325	·239	·019	·066	·001	22·66	16·83	5·83
6	Carbonate of Lime, 2·5 ,, -	·334	·242	·017	·065	·010	20·8	16·3	4·50
7	Bleaching powder, ·1 per cent. available Chlorine, - - - - -	·323	·239	·017	·062	·005	18·56	15·22	3·34
8	Formalin, ·1 per cent., - - -	·329	·249	·016	·057	·007	18·31	15·23	3·08
9	Chloroform, ·1 ,, - - -	·342	·246	·010	·072	·014	18·0	14·82	3·18
10	A Covering of 3 inches of Soil, -	·366	·277	·019	·063	·007	20·83	16·29	3·54
11	Consolidated, - - - - - -	·360	·261	·017	·072	·010	19·3	15·71	3·59
12	Loosely Packed, - - - -	·316	·247	·026	·04	·003	17·26	13 96	3·66

The analytical figures given in the previous table are in each case the average of two tests. The duplicates in some cases did not agree very closely, but this is not surprising, since the errors of an experiment of this nature are inevitably considerable. Treatment producing distinct differences can, therefore, only be taken into account.

From the table it will be seen that the manure treated as in Nos. 10 and 11 was richest in total nitrogen after storage, and that the treatment of No. 12 left the manure practically the poorest in nitrogen. The manure treated as in No. 12 was also poorest in ammoniacal nitrogen and in organic matter. No distinctive feature is manifest in the table from the result of the other tests; it should, however, be remarked that the addition of the antiseptics to the manure, judging from the characteristic putrifying odour of the manure, must have altered the nature of the fermentation which manure normally undergoes during storage in the absence of an antiseptic.

The percentage losses in nitrogen in the manure differently treated are given in Table XVIII., page 212.

TABLE XVIII.

Number of Experiment.	Preservative or Antiseptic.	Nitrogen.				Organic Matter.
		Total.	Insoluble.	Soluble Protein.	Ammoniacal.	
1	Superphosphate, ·25 per cent. Acid Salt, - - - - - - -	11·7	8·3	47·7	13·4G	11·7
2	Kainit, 1 per cent., - - -	15·2	9·3	67·3	2·9G	12·4
3	Gypsum, 2 ,, - - - - -	4·9	1·3G	39·0	3·4G	4·4
4	Sodium Acid Sulphate, ·5 per cent.,	7·8	5·8	39·3	12·6G	7·6
5	Carbonate of Lime, 5 ,,	13·0	8·3	48·2	6·7G	1·5
6	Carbonate of Lime, 2·5 ,,	5·6	3·1	42·6	7·9G	·5
7	Bleaching Powder, ·1 ,, available Chlorine, - - -	9·9	5·6	43·4	1·6G	8·3
8	Formalin, ·1 per cent., - - -	11·0	4·6	48·2	9·4	10·9
9	Chloroform, ·1 ,, - - - -	5·2	3·4	66·9	17·3G	11·2
10	A Covering of 3 inches of Soil, -	5·5G*	7·7G	37·6	1·6G	3·3
11	Consolidated, - - - - - -	0·2	0·4G	44·9	14·8G	8·0
12	Loosely Packed, - - - - -	14·8	5·6	16·1	36·7	18·8
	Average Loss, - - - - - -	7·9	3·7	45·1	3·0G	8·2

G = gain.

* The Soil was unfortunately weighed along with the Manure at the end of the Experiment and would account for this gain.

The best treatment for preserving the nitrogen compounds in the manure was that of Nos. 10 and 11. The treatment of No. 10 was to cover the well-packed manure with a 3-inch layer of soil, and that of No. 11 was to trample well, and thereby consolidate the manure. The treatment with chloroform and gypsum gave the next best result. In some cases, notably when superphosphate and kainit were employed, the effect was to increase appreciably the loss of nitrogen, a result confirmed by other investigators.

The column showing the loss or gain of ammoniacal nitrogen is instructive. In all cases, with the exception of Nos. 8 and 12, there was a definite but varying gain of ammonia. The gains from treatments Nos. 1 and 4 can no doubt be attributed to the acid substances used, and to consequent fixation of some of the ammonia in the form of ammonium salts. The largest gain was that effected by the addition of chloroform; that produced by the addition of formalin was also large. It is possible that the antiseptics added set up conditions in the manure which were more favourable to the growth of the ammonia-producing bacteria. Unfortunately it was not possible to have a bacterial examination of the treated manures made, but experiments with this object in view are now being conducted. Consolidation effected an appreciable gain of ammonia in the manure, whilst by loosely packing the manure a distinct loss occurred.

Slight increases in the amount of insoluble nitrogen compounds were recorded in a few cases.

The losses in organic matter are interesting if we are to take the rate of destruction as an index of bacterial activity. The treatment of No. 12, where the loss was greatest, seems, therefore, to approach nearest to those biological conditions under which the most rapid destruction of organic matter takes place. As heat is produced in the destruction of organic matter, the temperature readings should afford some information of the rate of destruction of the organic matter. For this reason the temperature of the manure in the boxes was taken every few days for a month, dating from the commencement of the experiment. The readings are given in Table XIX., page 214. The figures given are in each case the average temperature of the manure in two boxes where the treatment was alike.

TABLE XIX.

TEMPERATURES—DEGREES FAHRENHEIT.

Date 1908.	14/2	17/2	19/2	21/2	25/2	27/2	29/2	2/3	4/3	7/3	10/3	12/3
Air Temeprature, -		7·3	6·1	8·2	6·0	4·0	2·7	3·8	3·2	5·0	6·7	4·0
Experiment 1, -	9·35	7·5	7·15	7·25	6·55	6·25	5·55	4·55	4·45	4·4	5·1	5·75
,, 2, -	9·05	6·6	6·3	6·1	5·6	5·55	5·2	4·0	3·6	3·5	4·0	4·5
,, 3, -	9·5	7·15	6·9	6·65	6·0	5·7	5·25	4·1	4·0	4·05	4·5	4·95
,, 4, -	9·7	7·25	7·0	6·9	6·3	6·1	5·65	4·85	4·8	4·85	5·15	5·6
,, 5, -	9·1	7·2	6·9	6·65	6·15	6·05	5·7	4·9	4·35	4·3	4·6	5·1
,, 7, -	9·5	7·25	6·95	7·1	6·75	6·2	5·85	4·9	4·75	4·8	5·0	5·45
,, 8, -	8·5	7·3	6·85	6·7	6·05	5·75	5·0	4·2	4·05	4·0	4·7	4·95
,, 9, -	9·2	8·15	7·35	7·3	6·8	6·4	6·0	5·3	4·75	4·4	5·0	5·35
,, 10, -	8·55	7·35	6·5	6·15	5·95	5·65	5·1	4·2	3·95	3·8	4·3	4·85
,, 11, -	8·4	7·45	6·35	6·2	5·75	5·5	5·0	4·2	3·9	3·7	4·0	4·45
,, 12, -	16·9	16·0	15·05	13·6	13·25	12·3	11·25	10·0	9·35	8·75	9·15	9·55

With the exception of the manure in experiment No. 12, the temperatures of the differently treated lots of manures were much the same, any variation recorded coming within the limits of experimental error. The high temperature recorded throughout for treatment No. 12 coincided with the relatively large loss of organic matter recorded. Air would circulate more freely through the loosely-packed manure, furnishing an increased supply of oxygen to the aerobic bacteria, and resulting in accelerated oxidation changes as shown by the rise in temperature. The higher temperature would assist in the volatilisation of the ammonia; likewise the dilution of the carbon dioxide in the manure with air would also facilitate the dissociation of ammonium carbonate to ammonia and carbon dioxide. Clearly, a loosely-packed manure heap is a condition which should be avoided. On the other hand, a sodden and tightly compressed manure heap is a condition to be aimed at. At the end of a month, when the reading of the temperature was discontinued, the rate of oxidation had somewhat slowed down, as shown by the smaller differences between the temperature of the manure and that of the surrounding air.

The percentage of the different forms of nitrogen in the total nitrogen of the untreated and treated manures is given in Table XX.

TABLE XX.

No.		Percentage of Total Nitrogen.			
		Insoluble.	Soluble Protein.	Ammoniacal.	Amide and Nitrate.
	Fresh Manure, - - -	70·6	8·4	17·0	4·0
1	Superphosphate, ·25 per cent., Acid Salt, - - - -	73·2	4·9	21·9	...
2	Kainit, 1 per cent., - -	75·5	3·2	20·7	0·6
3	Gypsum, 2 per cent., - -	75·2	5·4	18·5	0·9
4	Sodium Acid Sulphate, ·5 per cent., - - - - -	72·2	5·5	20·8	1·5
5	Carbonate of Lime, 5 per cent.,	74·4	5·0	20·9	...
6	Carbonate of Lime, 2·5 per cent.,	72·5	5·1	19·5	2·9
7	Bleaching Powder, ·1 per cent., available Chlorine, - -	74·0	5 3	19·2	1·5
8	Formalin, ·1 per cent., - -	75·7	4·9	17·3	2·1
9	Chloroform, ·1 per cent., -	71·9	2·9	21·0	4·2
10	A Covering of 3 inches of Soil,	75·6	5·2	17·2	2·0
11	Consolidated, - - -	72·5	4·7	20·0	2·9
12	Loosely Packed, - - -	78·1	8·2	12·6	1·1
	Average of 1 to 12, -	74·2	5·0	19·1	...

The figures in this table are also instructive. A comparison of the figures obtained for the fresh manure with those for the various treated manures shows that in the treated manures, with the notable exception of the manure treated as in No. 12, the proportion of insoluble nitrogen compounds and of ammoniacal nitrogen increases, whilst the proportion of soluble protein decreases during storage.

To be of any practical worth, the substance used as a conserver of nitrogen should, by its addition to the manure, reduce the loss of this element, and thereby increase the value of the manure by sufficient to pay for the preservative, and also for the labour involved in its application. At the same time, it should have no detrimental effects on the value of the manure for manurial purposes. If we take as the standard of comparison the treatment of Nos. 10 and 11, which cost nothing except the labour, none of the substances used in the present experiment repaid their cost.

The treated manures were afterwards applied to an oat crop, but owing to the want of uniformity in the land chosen, the results obtained were unreliable.

SUMMARY.

Of the substances added to the manure to fix ammonia, gypsum and sodium acid sulphate were the most efficient, but super-phosphate of lime, kainit, and carbonate of lime, on the other hand, increased the loss of nitrogen. Of the antiseptics added to check fermentation, chloroform acted best, followed by bleaching powder and formalin. The reduction in the loss of nitrogen, where such occurred, was, however, not sufficient in any case to repay the cost of the substance used.

The most effective method of preserving the manure from losses of nitrogen was to trample the manure and to cover it with a 3-inch layer of soil. The least effective method was to leave the manure loosely packed.

The effect of the loosely-packed condition of the manure, compared with that in the other treated manures, on the losses during storage was to accelerate the changes resulting in (*a*) the destruction of organic matter, (*b*) the breaking down of the complex forms of nitrogen into amides and ammonium salts, and the subsequent dissociation of the ammonium salts into ammonia, changes aided by the higher temperature and the freer circulation of air.

In the trampled manure the conditions causing loss of nitrogen were controlled and the loss reduced to a minimum.

There was in addition an increase in the more available forms of nitrogen. The nearest approach in practice to these conditions is to allow the manure to accumulate in a sodden condition under the feet of the animal, such as occurs in a loose-box, or when the loaded carts are drawn up on to the top of the manure heap when it is being made in the field.

The conditions prevailing in the loosely-packed manure is one commonly occurring in practice, such as may be seen, for example, when the manure is carted daily from the byre, piggery, or stable on to a heap without any attempt at consolidating the loosely packed manure.

The value of farmyard manure, as shown in the previous experiments, will primarily depend upon the percentage of the available manurial compounds supplied by the urine; hence it follows that, unless the bulk of the urine is retained in the litter or dung, or collected in a tank, the best of the manure is going to waste.

THE TIME AND METHOD OF APPLICATION OF FARMYARD MANURE TO THE LAND.

In the foregoing experiments attention has been largely directed, to the losses in fertilising material which occur in fresh farmyard manure during storage, and to methods of restricting these losses. In the present and subsequent experiments attention will be directed principally to the losses which the manure is likely to sustain after its application to the soil, and to the influence which the time and method of application of the manure has upon these losses.

It has already been shown, page 200, that the chemical composition of farmyard manure, under average soil conditions, provides a useful measure of its manurial value. As shown on pages 197 and 198, farmyard manure contains between 20 and 30 per cent. of the total nitrogen, 40 and 50 per cent. of the total phosphoric acid, and between 70 and 75 per cent. of the total potash in the form of compounds which are soluble in water. Therefore, when the manure is incorporated with the soil, a relatively large proportion of the mineral constituents and a much smaller proportion of the nitrogen compounds will be available for immediate assimilation by crops.

Besides supplying the soil with nitrogen compounds, phosphates, and potash salts, farmyard manure fulfils other functions; one of the most important of these is the improvement in the mechanical and biological conditions of the soil, which invariably follows applications of farmyard manure, and which is mainly due to the introduction into the soil of the organic matter contained in the manure. This improvement is more pronounced in the more extreme types of soil; the texture of clay soils is rendered more open and consequently they are less sticky, and the soil becomes more permeable to air and to water, and more amenable to cultivation; whilst in the case of sandy soils the

effect is the opposite. The addittion of organic matter increases their absorptive and retentive power for water, and generally improves their physical condition. In dry situations and on light soils the water supply is often the deciding factor in soil fertility, and in such cases the effect of applications of farmyard manure is of the greatest importance, as it would increase the water content of the soil.

The improved physical condition produced by the organic matter soon reacts upon the organisms in the soil. Under the more suitable soil conditions the micro-organisms multiply at a greater rate, with the result that the organic matter upon which they feed is broken down more rapidly. The readily decomposable compounds in the manure are attacked first; some of the carbon which they contain is oxidised to carbon dioxide, and part of the hydrogen to water; part of the nitrogen content is converted into ammonia and nitric acid, part into nitrogen which escapes in the free state. A brownish coloured product called humus is left, which however, unless replenished, will slowly diminish under favourable soil conditions, and in time it likewise will be completely converted by further bacterial action into the substances mentioned above. The more stable and protected organic compounds of the manure are subjected to the same decomposing processes, but the rate of change is much slower.

The destructive changes which go on in the soil are similar to those which take place in the manure heap. For the soil, like the manure heap, is inhabited by many types of bacteria, protozoa, fungi, &c. The general soil conditions, principally the supply of air, water, and carbonate of lime, will determine to a great extent the nature and the type of the organisms, and these, perhaps, will indirectly exert a predominating influence upon the soil fertility. It will thus be more readily understood why crops grown on one type of soil, under one set of conditions, respond better to farmyard manure than the same crops grown on other types of soils under another set of conditions. Since it may happen that one set of conditions favours changes, as the result of which a great proportion of free nitrogen is evolved and lost; under

other conditions a larger proportion of the combined nitrogen is converted into ammonia and nitrates, compounds which the plant can utilise. However, nitrates, unless taken up by the crops, may suffer loss by being washed out in the drainage water. In the case of the mineral substances in the manure, loss by drainage is prevented by the phosphates and potash salts interacting with the soil constituents, and forming combinations which are not readily washed out.

That losses in the nitrogen compounds of the manure occur as the manure decays in the soil is a well-established experimental fact.* The total nitrogen recovered by a crop from farmyard manure in the first year after its application to the soil amounts to about 30 per cent. of the nitrogen supplied in the manure, compared with about 70 per cent. when the nitrogen is applied in the form of nitrate of soda. In this latter case practically all the nitrogen ever likely to be recovered is removed in the first crop, whereas in the case of farmyard manure a slowly changing humus is left in the soil, which benefits to some extent subsequent crops; but the total nitrogen recovered from the manure by the subsequent crops is found to be relatively small, and there is a big discrepancy between the quantity of nitrogen supplied to the soil in the manure and the quantity of nitrogen recovered in the crops. The type of soil, the climate, the time and the method of application of the manure, and the kind of crop to which the manure is applied will affect the amount of nitrogen recoverable.

In practice the time and method of application of the manure will depend upon a variety of circumstances, but whichever course is followed, whether the manure is applied in the autumn or in the spring, losses will always occur. The question which, under a certain set of conditions, is the better course to follow is put to the test in the present experiment.

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* See results of Rothamsted experiments.

The Scheme of the Experiment is as follows:—

Plot 1.—Received fresh farmyard manure, applied broadcast on stubble at the rate of 20 tons per acre in the autumn, and ploughed in at once.

Plot 2.—Received fresh farmyard manure, applied broadcast on stubble at the rate of 20 tons per acre in the autumn, and ploughed in after several months.

Plot 3.—Received fresh farmyard manure, applied in drills in spring, at the rate of 20 tons per acre.

Plot 4.—Received the residue from 20 tons of fresh farmyard manure, after rotting in a heap in the field through the winter, applied in drills in spring.

Plot 5.—Received rotted farmyard manure, applied at the rate of 20 tons per acre, in drills in spring.

Plot 6.—Received no manure.

The different methods were tested with two distinct rotations of crops running simultaneously, but in each case the manure was applied to the two root crops. The other crops were grown in order to measure the extent and the duration of the manurial residue left in the soil after the first year.

The two rotations were—

No. 1. Potatoes, wheat, seeds, oats.

No. 2. Turnips, barley, seeds, oats.

The experiment with each rotation has been repeated three times, and the fourth rotation is now in progress. As nearly as possible similar ground was used for each rotation, except in the experiment commencing in 1909, which was carried out in an adjoining field.

The plots were $\frac{1}{40}$th of an acre, and each plot in each rotation was quadrupled, except in the experiment commencing in 1909, when $\frac{1}{20}$th acre plots in duplicate were laid down. The figure given for any one plot for each year is, therefore, the average of four plots, except in 1909, when it is the average of two plots. The average yield represents the results of one plot over all the experiments, and is the average of fourteen plots, except when otherwise stated.

Table XXI. below gives the yield of the two root crops for the different years.

Table XXI.

Potatoes—Yield per Acre.					Turnips—Yield per Acre.			
1902.	1906.	1909.	1913.	Average.	1902.	1906.	1909.	Average.
T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T, C. Q.
11 18 1	9 8 2	5 7 1	11 6 0	9 10 0	25 16 3	22 4 1	8 18 3	19 0 0
10 17 3	10 0 1	4 18 1	11 16 0	9 8 0	25 3 3	21 16 3	8 3 2	18 8 0
14 3 1	12 18 0	7 7 0	14 16 0	12 6 0	30 11 0	25 3 3	10 13 2	22 2 3
12 18 1	10 8 3	7 9 3	13 3 0	11 0 0	26 14 1	24 0 2	9 8 2	20 1 0
...	...	7 14 3	13 11 0	10 12 3	...	...	9 14 2	...
9 3 0	6 12 2	4 15 2	9 1 0	7 8 0	22 0 3	15 9 1	7 8 1	14 19 2

The results of the different plots are sufficiently interesting to warrant a careful study of the contributing causes.

The soil: its general properties, mechanical and chemical composition, are given on page 201. It will be seen from the soil conditions that the water supply in the soil, in so far as it may be affected by the different methods of applying the manure, will not have any decided influence on the results.

The autumn applied manure.—Plots 1 and 2. These plots represent the practice when, instead of storing the fresh manure through the winter, it is applied to the land in autumn. In the drier climate and with the lighter soils, such as commonly occur in the South of England, it is almost a universal practice to winter manure for the root crops. By this means the organic matter of the manure, which becomes incorporated with the soil while the land is being cultivated, adds greatly to the water-holding and drought-resisting power of the soil, consequently to the stock of moisture available for the germination

of the seed and for subsequent requirements of the crop. Further, when left as a covering on the surface, the manure acts as a protection against evaporation of water. Under conditions such as those described, the water-holding function of the manure in the soil completely obscures any other effects which the manure may have.

Except perhaps on the sandy soils, such as border the coast of Ayrshire and Wigtownshire, and on some light gravels, the question of water supply, though important, does not, for reasons already stated, exert the same potent influence in soil fertility in the West of Scotland as it does in some other parts.

A main reason in the West of Scotland for the practice of applying manure to the soil in the autumn—which is a common practice on the sandy soils above referred to—is for a more equable distribution of labour through the year. It serves to relieve the pressure of work in the busy spring months. This is no doubt one reason why in some localities the manure is applied to the seeds instead of to the root crop in the rotation.

Undoubtedly the fresh manure applied in the autumn will, with its decay in the soil, increase the ameliorating and mellowing influences of the winter frosts, and a better seed-bed is more certain to follow. Likewise a more economical use is made of the organic matter compared with the storage of the manure in heaps, when a loss of between 20 and 30 per cent. of the organic matter occurs. In addition, the carbon dioxide evolved as the manure decays in the soil will help in the disintegration of the mineral constituents of the soil.

It is generally assumed that the soil is a good preserver of the constituents of the manure, and that by their incorporation with the soil the losses, which would otherwise occur by rotting the fresh manure in heaps, are avoided. This assumption, however, is not borne out by the results of this experiment. If we take the crop increase from the autumn and spring applied manures to be a rough measure of the fertilising material at the disposal of the crop, then the results of the experiment with the first crop convincingly point to greater losses occurring in the autumn applied manure. It hardly

matters whether the manure is ploughed in directly it is applied, or whether it is left on the stubble some months before ploughing in, or whether applied in the ridges and left there through the winter, the losses, when judged by the yield of the first crop, are equally great, although the manure residues must also be taken into account in this connection. When the manure is applied in the autumn the soil conditions are still favourable for bacteriological action, and any ammonium salts present in the manure, or which may be produced from the decay of the manure in the soil, would at once nitrify. The nitrate formed, with no crop growing except perhaps a few weeds, would in a wet winter be mostly washed out in the drainage water. Free nitrogen might also be evolved, either by putrefaction or oxidation of some of the nitrogen compounds in the manure.

The experiment on page 189 shows that the response by crops to farmyard manure, under the soil and climatic conditions prevailing at Kilmarnock, depends upon the supply of nitrogen in the manures.

The figures in Table XXII. afford further evidence of this. In plot 1, 20 tons, and in plot 2, 16 tons of farmyard manure were applied to both a potato and to a turnip crop.

TABLE XXII.

lot.	Percentage of Nitrogen in Manure.			Weight of Nitrogen applied in Manure, in lbs. per acre.			Yield of Unmanured Plot=100.	
	Total.	Ammoniacal and Amide.	Soluble Protein.	Total.	Ammoniacal and Amide.	Soluble Protein.	Potato. Average of 14 Plots.	Turnip. Average of 14 Plots.
1	·342	·081	·032	153	37	14	164	148
2	·350	·051	·025	125	18	9	150	134

The plots receiving the larger dressing of manure have given the larger yields of potatoes and turnips. The increased yield of Plot 1 over Plot 2 is in close agreement for both crops, and amounts to about 14 per cent. in each case.

The results obtained from rotted manure, applied at the rate of 20 and 16 tons per acre respectively to potatoes and turnips, in Table XXIII. below, are equally instructive.

TABLE XXIII.

Percentage of Nitrogen in Manure.		Weight of Nitrogen applied in Manure—lbs. per acre.		Yield of Unmanured Plot=100.	
				Potato.	Turnip.
Total.	Soluble.	Total.	Soluble.	Average of 6 Plots.	Average of 4 Plots.
·375	·078	168	35	156	131
·375	·078	135	29	151	127

A smaller percentage difference is obtained in this case, but the difference is in the same direction. The difference between the total weight of nitrogen supplied is greater than in the previous experiment, but that between the soluble nitrogen compounds is less. The figures in the two tables are important, in that they show that it is the soluble nitrogen constituents of the manure which are mostly made use of by crops in the year of application of the manure. This shows that a higher value for manurial purposes must be attached to the soluble compared with the insoluble nitrogen compounds of the manure. The increased yield from the larger dressing of manure also means that the crop is not getting as much available nitrogen from the soil as it requires, and that it is obtaining this deficiency from the manure. The other constituents of the manure are presumably already better provided for in the soil, and those, therefore, contained in the manure are not in the same favourable position as the nitrogen compounds for exercising any decided influence on plant growth. It would appear then that the larger crop yields from the spring applied manure, compared with the smaller yields from the autumn applied manure, are evidence of greater losses, or, perhaps, of a greater

locking up of the nitrogen compounds in the soil in a less available form in the case of the autumn compared with the spring applications.

As the manure applied in the autumn was broadcasted and that in the spring applied in the drills, the difference in yield of the various crops found between the two applications might be attributed to the difference in the method of applying the manure.

The results of an experiment to test this point are given in Table XXIV.

TABLE XXIV.

20 Tons Rotted Manure applied in Spring.	Yield of Potatoes. Mean of 3 Plots.			Yield of Unmanured Plot=100.
	Tons.	Cwts.	Qrs.	
In Drills, - -	12	8	0	137·0
Broadcast, - -	11	12	3	128·0
Unmanured, -	9	1	0	...

The figures show that the yield of potatoes is affected according as the manure is applied broadcast or in drills. The concentration of the manure in the drills will no doubt enable root crops, with their somewhat limited root development, to extract more out of the manure than when the manure is in the more scattered state after broadcasting. The difference of about 9 per cent. in favour of the manure applied in drills will partially explain the difference in yields found between the spring and autumn applications, but as the increased yield of the autumn over the spring applications amounts to about 38 per cent. with potatoes, and 24 per cent. with turnips, the 9 per cent. does not account for the main difference in yields. This, as already pointed out, must be attributed to the relative supplies of nitrogen at the disposal of the crop in the two methods of application of the manure.

Spring application of the manure.—Plots 3, 4, and 5. These plots represent the practice of applying the manure fresh or rotted in drills in spring. Instead of putting the fresh manure on to the land in the autumn, it is stored in heaps until it is required for application in the rotted state in the spring. The immediate effect of ploughing-in the manure is to form a mulch, which dries the soil to the depth to which it is disturbed; at the same time it brings about a reduction of the losses of water from the subsoil.

In a dry spring, on a light soil, the effect of mulching in drying the surface soil might hinder germination and the subsequent development of the young plant. The short-rotted manure, however, is less liable to dry the soil than the long, coarser, fresh manure. In a wet spring, therefore, or on a heavy soil, the forming of a mulch to dry the surface soil would, for obvious reasons, be exceedingly beneficial.

Extra expense is incurred in the rotting of the manure, and the carting of the manure on to the land comes at a time in the spring when sowing and other important farming operations are requiring immediate attention, so that where the practice of spring applications is followed there must be some very good reasons in its favour, when the risk it involves of delaying urgent spring work is incurred.

The reason for this practice is shown by the results of this experiment, where the spring applied manure has proved superior, both with potatoes and turnips, in each of the four years in which the experiment was started.

Season caused a considerable variation from the average, but in no year was the modification sufficient to alter the main result. The meteorological conditions since 1902 are given on page 251.

For the purpose of more detailed comparison, Tables XXV., XXVI., and XXVII. give the increased yield per acre of the first crop, namely, potatoes and turnips, over the unmanured plot in weight, in money value, and in percentages.

TABLE XXV.

Plot	Potatoes—Increase over Unmanured Plot.					Turnips—Increase over Unmanured Plot.			
	1902.	1906.	1909.	1913.	Average.	1902.	1906.	1909.	Average.
	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.
1	2 15 1	2 16 0	0 11 3	2 5 0	2 2 0	3 16 0	6 15 0	1 10 2	4 0 2
2	1 14 3	3 7 3	0 2 3	2 15 0	2 0 0	3 3 0	6 7 2	0 15 1	3 8 2
3	5 0 1	6 5 2	2 11 2	5 15 0	4 18 0	8 10 1	9 14 2	3 5 1	7 3 1
4	3 15 1	3 16 1	2 14 1	4 2 0	3 12 0	4 13 2	8 11 1	2 0 1	5 1 2
5	...	...	2 19 1	4 10 0	3 15 0	...	...	2 6 1	...

TABLE XXVI.

Plot.	Potatoes—Value of Increase over Unmanured Plot.					Turnips—Value of Increase over Unmanured Plot.			
	1902.	1906.	1909.	1913.	Average.	1902.	1906.	1909.	Average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	6 4 0	6 6 0	1 7 0	5 1 0	4 14 0	1 10 0	2 14 0	0 12 0	1 12 0
2	3 18 0	7 12 0	0 6 0	6 3 0	4 10 0	1 5 0	2 11 0	0 6 0	1 7 0
3	11 5 0	14 2 0	5 16 0	12 19 0	11 0 0	3 8 0	3 18 0	1 6 0	2 17 0
4	8 9 0	8 11 0	6 2 0	9 4 0	8 2 0	1 17 0	3 8 0	0 16 0	2 0 0
5	...	...	6 13 0	10 2 0	8 7 6	...	...	0 18 0	...

Turnips were valued at 8s. and potatoes at 45s. per ton.

TABLE XXVII.

Plot.	Potatoes—Unmanured Plot=100.					Turnips—Unmanured Plot=100.			
	1902.	1906.	1909.	1913.	Average.	1902.	1906.	1909.	Average.
1	130	142	112	125	127	117	143·5	121	127
2	119	151	103	130·5	126	114	141	110	122
3	154·5	194·5	143	163·5	164	138	163	144	148
4	141	157·5	156·5	145·5	150	121	155	127	134
5	...	...	161·5	150	156	...	...	131	...

The autumn applications compared.—Plot 1 received 20 tons fresh manure applied broadcast on the stubble, and ploughed in at once. Plot 2—The same as Plot 1, except that several months elapsed before the manure was ploughed in. In the experiments in 1902 and 1909 the yield of potatoes in Plot 1 was 10 per cent. higher than that of Plot 2. In the experiments in 1906 and 1913 the position was almost exactly reversed. Thus the average yields for the two plots over the four experiments are almost alike for potatoes. With turnips, Plot 1 was consistently better than Plot 2, the superiority amounting to about 5 per cent. on the average.

The spring applications compared.—Plot 3 received 20 tons of fresh manure, applied in drills, while Plot 4 the residue from 20 tons fresh manure after rotting through the winter, and applied in drills. Plot 5 received 20 tons of rotted manure applied in drills. Except with potatoes in the 1909 experiment, the fresh manure in Plot 3 gave uniformly better results with both potatoes and turnips than the residue from the same quantity of fresh manure applied after rotting, as in Plot 4. This result is in accord with the larger amount of the more available nitrogen compounds supplied in the fresh manure. In rotting, the 20 tons of fresh shrinks to about 16 tons of rotted manure (see page 189), so that in the two plots we are comparing the effects of 20 tons of fresh with about 16 tons of rotted manure. The difference in the total weight of nitrogen supplied in the manure to the two plots is due to the nitrogen lost in rotting, and the difference in the crop yields represents the crop value of the fertilising material lost. The superiority of Plot 5 over Plot 4, and in 1909 over Plot 3, can be attributed to the same cause.

Autumn and spring applications compared.—The spring applied manures, taking the average of Plots 3, 4, and 5, give an increased yield of 57 per cent. with potatoes, and of 41 per cent. with turnips, or with both crops an average increase in yield of about 50 per cent. over the unmanured plot. The autumn applied manures, taking the average of Plots 1 and 2,

give an increase in yield of 26 per cent. with potatoes, and of 24 per cent. with turnips, or an average increase with both crops of about 25 per cent. over the unmanured plot. The average increased yield, therefore, in the case of the spring applied manures is just double that of the manure applied in the autumn.

The average increase in money value of potatoes for the spring applications amounted to £9 3s. and in the case of turnips to £2 8s. For the autumn application the value of the average increase of potatoes amounted to £4 12s., and of turnips to £1 9s. The difference between the spring and autumn applications of the manure to both crops leaves a large margin in favour of the former method. The average increase in yield for the five plots over the unmanured plot is given in Table XXVIII.

TABLE XXVIII.

Plot.	Potatoes— Increase over Unmanured Plot.							Turnips— Increase over Unmanured Plot.						
	Weight per acre.			Money Value per acre.			Percentage.	Weight per acre.			Money Value per acre.			Percentage.
	Tons.	Cwts.	Qrs.	£	s.	d.		Tons.	Cwts.	Qrs.	£	s.	d.	
1	2	2	0	4	14	0	127	4	0	2	1	12	0	127
2	2	0	0	4	10	0	126	3	8	2	1	7	0	122
3	4	18	0	11	0	0	164	7	3	1	2	17	0	148
4	3	12	0	8	2	0	150	5	1	2	2	0	0	134
5*	3	15	0	8	7	6	156	...			...			...

*Average of two years.

It is generally held in support of the autumn applications that the proportion of marketable potatoes is larger than in the case of the spring applied manure. The average percentage of marketable potatoes in the separate plots was as follows :—

	Plots	1	2	3	4
Marketable potatoes percentage,	...	80	79	79	78

The figures are slightly in favour of the autumn applied manure.

The percentage of nitrogen in the potato tubers and in the turnip roots and shaws was determined. Analysis of the manure was also made. From these figures, along with the weight of manure applied and the crop increases obtained, the amount of nitrogen added in the manure and recovered in the crop increases has been calculated, and the figures set out in the following Table XXIX.

Table XXIX.

Plot.	Nitrogen in Lbs.			Percentage.	
	Manure.	In Increased Weight of Potatoes.	In Increased Weight of Turnips.	Nitrogen recovered in Potatoes.	Nitrogen recovered in Turnips.
1	188	15·2	20·0	8·1	11·1
2	188	14·5	17·4	7·6	9·0
3	188	35·5	37·0	18·8	19·4
4	134	26·2	21·0	19·4	15·7
5	168	27·0	...	16·0	...

Only a relatively small part of the nitrogen added in the manure appears to have been recovered in the crop to which the manure was applied. The remainder is either left in the soil or lost through the channels already indicated. The yield of the succeeding crops should throw some light on this point.

Tables XXX. to XXXIII. give the average yield and the average increased yield per acre over the unmanured plot of the crops following potatoes and turnips respectively.

The complete rotation of crops was not maintained in the case of Plot 5, and the results for this plot are therefore left out in Tables XXX. to XXXIII.

TABLE XXX.

Average yield per acre.

Plot.	Potatoes.			Wheat.		Seeds—Hay.	Oats.*	
				Grain.	Straw.	Total Produce.	Grain.	Straw.
	Tons.	Cwts.	Qrs.	Lbs.	Lbs.	Cwts.	Lbs.	Lbs.
1	9	10	0	2335	4434	104·25	3595	4158
2	9	8	0	2343	4150	96·3	3587	4018
3	12	6	0	2535	4491	101·8	3710	4130
4	11	0	0	2214	3941	96·1	3692	4032
6	7	8	0	2036	3803	87·9	3111	3772

* Average, 1902 and 1906.

TABLE XXXI.

Average yield per acre.

Plot.	Turnips.			Barley.		Seeds—Hay.	Oats.*	
				Grain.	Straw.	Total Produce.	Grain.	Straw.
	Tons.	Cwts.	Qrs.	Lbs.	Lbs.	Cwts.	Lbs.	Lbs.
1	19	0	0	2823	4867	115	4193	4335
2	18	8	0	2728	4629	107·5	4150	4300
3	22	2	3	2922	4816	104·75	4268	4315
4	20	1	10	2706	4711	108·0	4020	3948
6	14	19	2	2371	4490	96·75	3915	4104

* Average, 1902 and 1906

TABLE XXXII.

Average increased yield per acre over unmanured plot.

Plot	Potatoes.			Wheat.		Seeds—Hay.	Oats.	
				Grain.	Straw.	Total Produce.	Grain.	Straw.
	Tons.	Cwts.	Qrs.	Lbs.	Lbs.	Cwts.	Lbs.	Lbs.
1	2	2	0	299	631	16·35	484	386
2	2	0	0	307	347	8·4	476	246
3	4	18	0	499	688	13·9	599	358
4	3	12	0	178	138	8·2	581	260

TABLE XXXIII.

Average increased yield per acre over unmanured plot.

Plot	Turnips.			Barley.		Seeds—Hay.	Oats.	
				Grain.	Straw.	Total Produce.	Grain.	Straw.
	Tons.	Cwts.	Qrs.	Lbs.	Lbs.	Cwts.	Lbs.	Lbs.
1	4	0	2	452	377	18·25	278	231
2	3	8	2	357	139	10·75	235	196
3	7	3	1	551	326	8·0	353	211
4	5	1	2	335	221	11·25	105	...

The increased yield over the unmanured plot, worked out in percentages, is given in Tables XXXIV. and XXXV., on the opposite page. In these tables the yield of the unmanured plot is taken as 100.

TABLE XXXIV.

Plot.	Potatoes.	Wheat.	Seeds.	Oats.
1	127	117	118	112
2	126	112	110	111
3	164	120	115	114
4	150	106	109	113
Average,	142	114	113	112

TABLE XXXV.

Plot.	Turnips.	Barley.	Seeds.	Oats.
1	127	113	108	106
2	122	108	106	105
3	148	114	102	100
4	135	110	98	97
Average,	133	111	104	102

These two last tables show that the crops following potatoes benefit to a much greater extent from manurial residues than the crops following turnips. At the end of the rotation there still seems to be an appreciable residue left in the soil from the manure applied to the potatoes, whilst practically no response is made by the last crop in the rotation when the manure was applied to turnips as the first crop. It would appear that the potato crop either takes less out of the manure than turnips, see figures in Table XXIX., page 232, or that the preparation of the land and its subsequent cultivation in the growing of potatoes causes smaller losses than is the case when turnips are grown.

The figures in Table XXXVI., page 236, bring out this point more clearly. The percentage increase of each of the crops in the rotation have been added together, and the increase with potatoes and turnips worked out as percentages of the total. The difference is due to the manurial residues.

TABLE XXXVI.

Plot.	Increases for the Four Crops—Total.		Percentage Increase of the Total.	
	Potato Rotation.	Turnip Rotation.	Potatoes.	Turnips.
1	74	54	36	50
2	59	41	44	54
3	113	64	56	75
4	78	40	64	87
Average,	81	50	50	66

The average figures in Tables XXXIV. to XXXVI. show that the potato crop responds better than the turnip crop to applications of the same quantity of manure. Farmyard manure alone is not a well-balanced manure for the latter crop; at the same time potatoes are only credited with 50 per cent., whilst turnips are credited with 66 per cent. of the total increase of the crops in the two rotations from the manure.

The figures indicate that some of the nitrogen compounds in the autumn applied manure, when ploughed in at once, are not really lost, but become temporary locked up in the soil in the form of more stable substances, which are only slowly broken down into available compounds.

The last two columns in Table XXXVI. are interesting. The figures not only indicate which method of the four tried provides the largest supply of available plant food for the first crop, but they show, in the case of the autumn applied manure in the potato rotation, that the manurial residues give an increased yield of crop larger than that produced in the year of application of the manure. In this rotation generally the effect of manurial residues is much more pronounced, amounting on an average to 50 per cent. of the total benefit accruing from the manure. In the turnip rotation the effect of the manure residues obtained was on an average only 34

per cent. of the total effect of the manure. The manuring of Plot 1 left the largest residue.

The autumn applied manure in the turnip rotation leaves a larger manurial residue than the spring applied manures, and for this reason gives a slower return, but it has a more lasting action.

The crop increases, for the different crops in the two rotations, and for the different methods of applying the manure, are shown graphically in the following diagrams :—

DIAGRAM No. II.

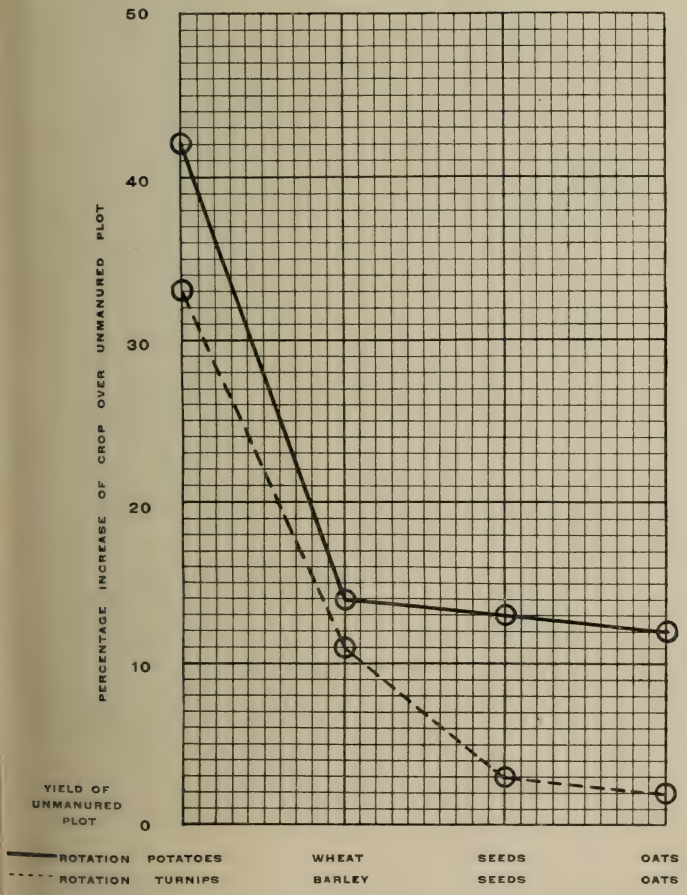


Diagram No. III.

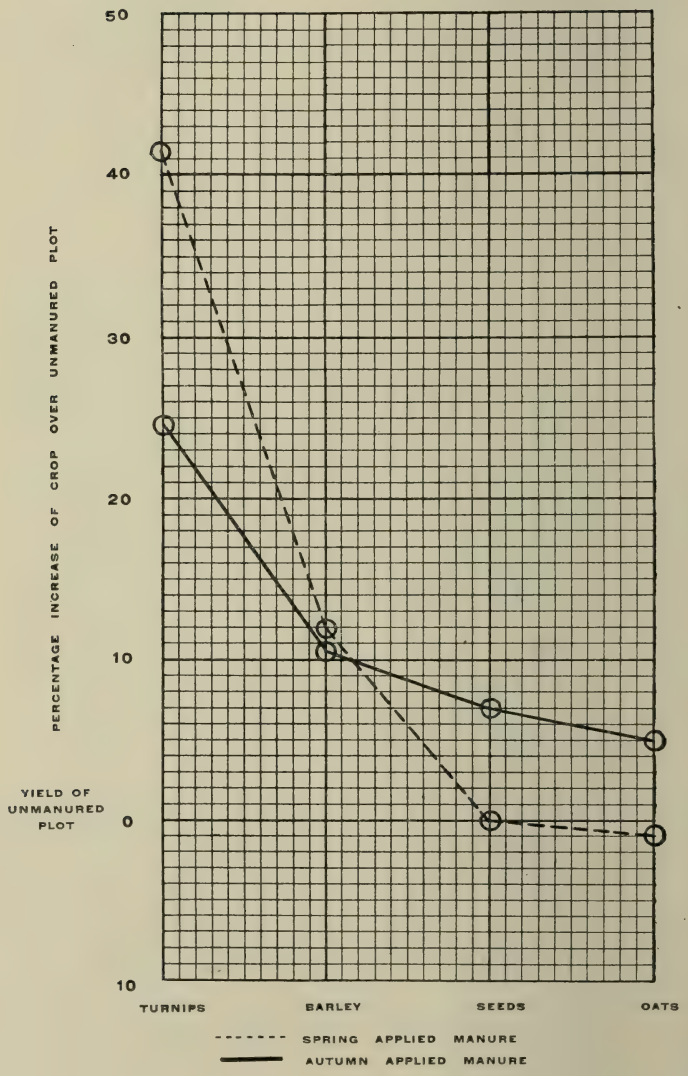
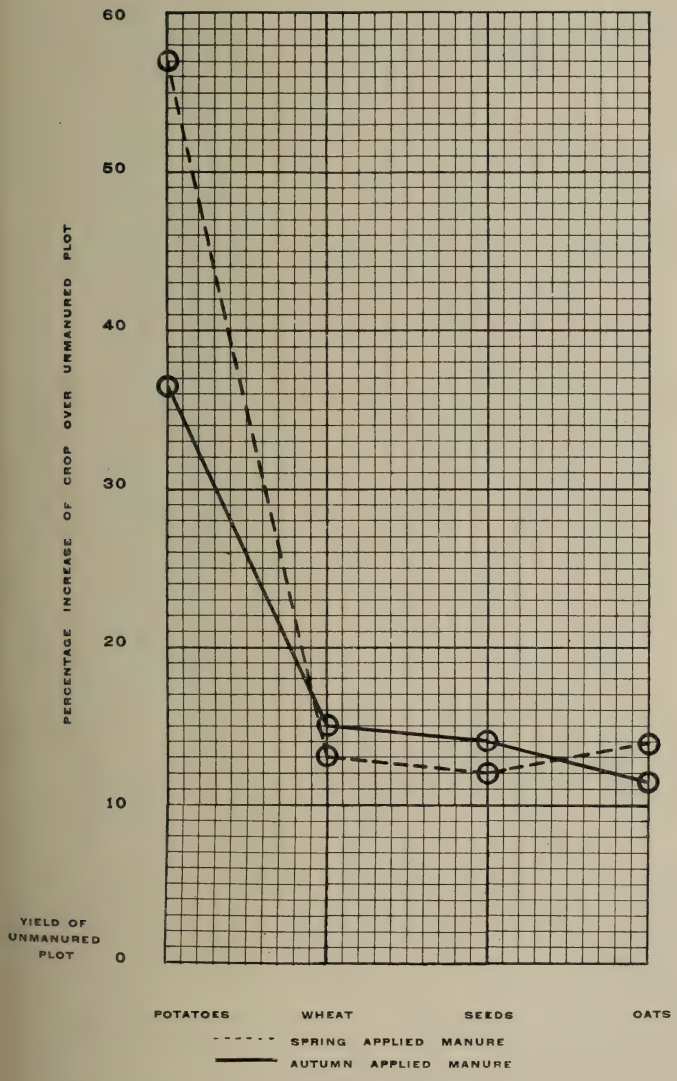


DIAGRAM No. IV.



The total nitrogen recovered from the manure during the rotation would not amount to more than between 30 and 40 per cent. of the amount added.

Tables XXXVII. and XXXVIII. give the money value per plot of the increases for all the crops in the rotation.

TABLE XXXVII.

Plot.	Potatoes.	Wheat.		Seeds.	Oats.		Total for the Rotation.
		Grain.	Straw.		Grain.	Straw.	
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	4 14 0	0 16 9	0 13 11	2 9 0	1 8 0	0 6 2	10 7 10
2	4 10 0	0 17 2	0 7 8	1 5 0	1 8 0	0 3 11	8 11 9
3	11 0 0	1 8 0	0 15 2	2 2 0	1 15 0	0 5 8	17 5 10
4	8 2 0	0 10 0	0 3 0	1 5 0	1 14 0	0 4 2	11 18 2
5	8 7 6						

TABLE XXXVIII.

Plot.	Turnips.	Barley.		Seeds.	Oats.		Total for the Rotation.
		Grain.	Straw.		Grain.	Straw.	
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	1 12 0	1 5 0	0 4 11	2 15 0	0 16 4	0 3 8	6 16 11
2	1 7 0	1 0 0	0 1 10	1 12 0	0 13 10	0 3 2	4 17 10
3	2 17 0	1 11 0	0 4 3	1 4 0	1 0 10	0 3 5	7 0 6
4	2 0 0	0 18 9	0 2 10	1 14 0	0 6 2	—	5 1 9

In the potato rotation the 20 tons of fresh manure applied in drills in spring, as in Plot 3, gave the best return. There is not much difference between the other plots. The larger manure residue of Plots 1 and 2 has reduced the advantage which Plot 4 otherwise held over these plots.

In the turnip rotation Plots 1 and 3 were much alike in the total value of the crop increases produced. Plots 2 and 4 were also very similar.

If the value of the manure be estimated at 6s. per ton, then the cost of 20 tons would be £6, which figure must be deducted from the total values given in the last column of the two tables. The difference is the profit.

The interpretation which has been put upon the figures obtained in this experiment is only applicable to the soil and climatic conditions prevailing whilst the experiment was in progress. Under other conditions very different results might be obtained.

SUMMARY.

In a comparison of the methods of applying farmyard manure to root crops, the different methods were found to give much the same results with both potatoes and turnips.

The application of the fresh manure broadcast to the soil in the autumn produced an average increased yield of roots of 25 per cent. over the yield of the unmanured Plot. If the fresh manure is stored until the spring, and the residue then applied in drills to the root crop, an average increased yield of 42 per cent. was produced, whilst when the fresh manure is applied in drills in spring the average increased yield was 56 per cent. About 9 per cent. of the increase for root crops of the drilled manures is due to the method of applying the manure in drills over that of broadcasting. In the case of the autumn application of manure, when the manure was applied to turnips, there was a 5 per cent. increase in favour of ploughing in the manure at once compared with leaving the manure on the surface some time before ploughing it in. When the manure was applied to potatoes there was not much to choose between the two practices.

The yield of the root crops from the manure, whether applied in the fresh or rotted state in the spring, depended upon the richness of the manure, as indicated by its chemical composition in the more active compounds of nitrogen.

Fresh manure applied to the land in the autumn for a root crop undergoes changes before the crop is sown which diminish its value as a manure for roots compared with the value of manure applied in the spring. Part of the active compounds of nitrogen in the manure is converted into less available forms, which as manurial residues afterwards become partly available for subsequent crops. Some of the combined nitrogen may be evolved in the free state, and in a wet winter there may be a considerable loss of nitrate. That this deterioration of the manure is serious is shown by the fact that if, instead of applying the fresh manure to the land in the autumn, it is stored during the winter, and the residue applied in drills in spring, a much larger increase in roots is produced. It follows, therefore, that the losses from the manure in the soil must be greater than the losses when the manure is stored. The result shows how profoundly the manurial value of farmyard manure for roots is determined by the treatment and the time of application of the manure.

The manurial residues from farmyard manure are considerably affected according to (*a*) the root crop to which the manure was applied, (*b*) the time of application of the manure.

(*a*) The manure applied to potatoes leaves a residue which produces an increase amounting on an average to 50 per cent. of the total increase produced from the manure by the four crops, including potatoes, in the rotation, whereas the manure applied to turnips leaves a residue amounting to 34 per cent. of the total increase for the four crops in the rotation. Moreover, the residue in the former case persisted and was not exhausted at the end of the rotation, whereas in the latter case its effect was hardly visible after the second crop.

(*b*) The residues left from the manures applied in the autumn were, as a rule, distinctly greater than the residues left from the same weight of manure applied in the spring. In the former case the increases due to manure residue amounted on an average to 57 per cent. of the total increase produced by the manure, whereas in the latter case it amounted to 34 per cent. of the total increase.

The nitrogen supplied in the manures and recovered by the root crop amounted on an average for potatoes and turnips to about 9 per cent. from the autumn applied manure, and to about 18 per cent. for the spring applied manure. For the whole rotation the amount recovered in the crops would not on an average be much over 30 per cent. of that supplied in the manure. Although the figures show that on the average more nitrogen is taken up by the crop than appears to be directly available in the manure at the time of its application, nevertheless considerably more than one-half of the nitrogen added in the manure is unaccounted for.

As to the merits of the different methods of applying the manures, Table XXXVI. (page 236) will give the best indication of the results for the whole rotation, and Table XXVII. (page 229) for effect on the root crops. The fresh manure applied in drills in the spring has throughout given the best results, both with the root crops and for the whole rotation. Although in the rotation when turnips was the root crop, the superiority is not so great. As a rule, the autumn applied manures, compared with the spring applied manures, gave a much poorer yield with the root crops, but a larger manurial residue was left, more pronounced in the rotation when turnips was the root crop. In this rotation the larger manurial residue levels up very considerably the differences found between the methods when the root crop only was considered. The financial results are given in Tables XXXVII. and XXXVIII., page 240.

It must be remembered that the climatic and soil condition under which the experiment has been carried on were such as to put the benefits accruing from the manures on the mechanical and physical condition of the soil at a considerable disadvantage, compared with the effect on light and heavy soils and in a dry climate.

The results of these experiments have, for the following special reasons, an important bearing upon the question of compensation for unexhausted manures :—

(1) About 30 per cent. of the total nitrogen in fresh manure, and a little less in rotted manure when it is stored in the open,

may be reckoned to be in an available form. The remainder is of less manurial value even as manure residues.

(2) On an average, between 40 and 50 per cent. of the phosphoric acid, and between 70 and 80 per cent of the potash, in farmyard manure is soluble in water.

(3) Between 20 and 30 per cent. of the total nitrogen, 10 and 20 per cent. of the total phosphoric acid, and between 25 and 35 per cent. of the total potash may be lost when fresh manure is stored in small heaps. If precautions against drainage are taken practically no loss of mineral matter need occur.

(4) When farmyard manure is applied to a root crop in a four course rotation, potatoes would account for about 50 per cent., and turnips for about 65 per cent. of the total increase of all the crops in the rotation. In the former case the manurial residue is not exhausted at the end of the rotation; in the latter it is practically exhausted by the 2nd crop.

(5) Farmyard manure yields, when applied in drills in spring to potatoes, about 60 per cent., and to turnips about 80 per cent., of its total manurial value for the rotation, compared to a yield of about 40 per cent. with potatoes and about 50 per cent. with turnips when the manure is applied broadcast in the autumn.

(6) Small dressings of manure, of about 10 tons, produce proportionately a better return with the first crop than large dressings of about 20 tons, but the latter leaves proportionately a larger residue than the former.

FRESH *v.* ROTTED FARMYARD MANURE.

This experiment was carried out on potatoes at Kilmarnock in the years 1909 and 1913. The plots were quadrupled in each year.

20 tons of fresh manure and 20 tons of rotted manure were applied in drills in spring.

The results per acre are given in Table XXXIX.

TABLE XXXIX.

Manure per Acre.	Potatoes.								
	1909.			1913.			Average.		
	Tons.	Cwts.	Qrs.	Tons.	Cwts.	Qrs.	Tons.	Cwts.	Qrs.
20 tons fresh manure, -	7	7	0	14	16	0	11	1	2
20 tons rotted ,, -	7	14	3	13	11	0	10	12	3
Unmanured, - - -	4	15	2	9	1	0	6	18	1

The yields from the two manures are governed largely by the amount of nitrogen available in the manures at the time of planting of the crop, or formed in the soil from the manure soon afterwards.

In some of the experiments on the storage of farmyard manure, pages 179 and 189, the losses of nitrogen were so great during storage that the rotted manure was left poorer in nitrogen than the fresh; but if ordinary precautions against undue losses are taken, the rotted manure should be left richer in total nitrogen than the fresh, but in all probability it will be poorer in the more available compounds of nitrogen, as the figures in Table XL. show. In comparing the two manures, it should also be remembered that 20 tons of fresh manure rots to about 16 tons on storage, so that when applied to the land in equal weights the former would go farther than the latter.

On average soils the composition of farmyard manure decides its value, but on light soils the short rotted manure produces better results than the long fresh manure. This latter condition is preferable for clay soils.

Table XL. gives the analysis of three lots of fresh manure, and the same rotted.

TABLE XL.

	Composition of Farmyard Manure in percentages.							
	Fresh.				Rotted.			
	1	2	3	Average.	1	2	3	Avera
Nitrogen, total - - -	·421	·271	·409	·367	·375	·326	·443	·38
,, insoluble - -	·309	·233	·342	·295	·297	·286	·403	·32
,, soluble protein -	·024	·040	·068	·044	·009	·041	·025	·02
,, ammoniacal - -	·076	·073	·135	·095	·021	·035	·036	·03
,, amides and nitrates	·012	...	...	·012	·048	...	·011	·03
Phosphoric Acid, P_2O_5 total	·229	·216	·264	.236	·225	·306	·328	·28
,, ,, ,, soluble	·096	·082	·183	·120	·093	·120	·083	·09
Potash, K_2O total - -	·421	·359	·521	·433	·376	·365	·496	·41
,, ,, soluble - -	·320	·333	·478	·377	·272	·335	·433	·34
Dry matter - - - -	19·96	20·30	21·55	20·60	19·15	21·8	21·01	20·6
Organic matter - - -	14·44	15·37	16·50	15·43	14·26	16·33	15·24	15·2
Ash - - - - - -	5·52	4·93	5·05	5·17	4·89	4·45	5·77	5·0
Storage, weeks - - -	18	19	17	18				

LARGE AND SMALL APPLICATIONS OF FARM-YARD MANURE COMPARED.

This experiment has been repeated a number of times at Holmes Farm, Kilmarnock. 20 tons and 10 tons of farmyard manure were applied to a potato and to a turnip crop respectively. Other crops were afterwards grown to ascertain the extent of the manurial residues. The effect of the addition of artificial manures to the 10 tons of dung was also tried.

The plots were 1-40th of an acre. Each figure given in the tables is the average result of 10 plots, except when otherwise stated.

Table XLI. contains for each plot (*a*) the increased yield per acre of potatoes and turnips due to the manuring, and (*b*) the money value of the increase. The potatoes were valued at 45s. per ton, and the turnips at 8s. per ton.

Table XLI.

Manures per Acre.	Increase over unmanured Plot per Acre.		Value of Increase per Acre.	
	Potatoes.	Turnips.	Potatoes.	Turnips.
	T. C. Q.	T. C. Q.	£ s. d.	£ s. d.
20 Tons Farmyard Manure, - -	5 0 1	7 0 0	11 5 6	2 16 0
10 ,, ,, -	2 17 2	5 12 2	6 9 4	2 5 0
10 ,, + Artificials*	4 15 2	8 0 0	10 14 10	3 4 0

* Potatoes received 4 cwts. of Superphosphate of lime. 1½ cwts. of Sulphate of Potash. 1 cwt. of Sulphate of Ammonia. Turnips received 4 cwts. of Superphosphate of Lime. ½ cwt. of Sulphate of Ammonia.

The increase in yield of potatoes for the large and small dressing of manure was practically in proportion to the supply of manurial ingredients in the two dressings of

manures. The addition of artificial manures to the small dressing of dung produced an increase equal to that produced by the large dressing of dung.

The cost of 20 tons of farmyard manure at 6s. per ton is £6. The cost of the artificials applied to the potato crop along with the 10 tons of manure was £2. So that the smaller dressing of manure, augmented with artificials, is a somewhat more economical practice than the large dressing alone.

The increase in yield of turnips was proportionately much larger for the small compared with the large dressing of manure. The small dressing of dung with artificials produced the largest yield of turnips at least cost.

Tables XLII. and XLIII. give the crop increases over the unmanured plot worked out in percentages (*a*) for the crops to which the manures were applied, and (*b*) for the crop increases due to the manurial residues.

TABLE XLII.

MANURES PER ACRE.	YIELD OF TOTAL PRODUCE OF UNMANURED PLOT = 100.			
	Potatoes.	Wheat.	Seeds.	Oats.
20 Tons Farmyard Manure, - -	169	116	116	111
10 ,, ,, -	140	97	97	99
10 ,, + Artificials	168	104	114	99

TABLE XLIII.

MANURES PER ACRE.	YIELD OF TOTAL PRODUCE OF UNMANURED PLOT = 100.			
	Turnips.	Barley.	Seeds.	Oats.*
20 Tons Farmyard Manure, - -	146	119	102	105
10 ,, ,, -	140	107	92	94
10 ,, + Artificials	158	107	92	95

* Average result of 4 Plots.

The large dressing of manure when applied to the potato crop left a manurial residue in the soil which produced quite a noticeable increase on the 4th crop following the application of the manure. When applied to the turnip crop the effect of the manurial residue from the large dressing of dung was hardly visible after the 2nd crop following the application of the manure.

The small dressing of dung applied to either potatoes or turnips left a manurial residue which produced no effect after the second crop following the application of the manure. The addition of the artificials did not alter the manurial residues, which shows that the artificial manures used were exhausted by the crop to which they were applied.

Table XLIV. gives the average results for the same experiment carried out at a number of centres in the West of Scotland in the years 1907 to 1910, inclusive.

Table XLIV.

Manures per Acre.	Mean of 16 Centres. 1907.	Mean of 14 Centres. 1908.	Mean of 8 Centres. 1909.	Mean of 12 Centres. 1910.	Average over all the Centres.
20 tons Fresh Farmyard Manure,	300	168	172	229	217
10 ,, ,, ,,	220	147	158	185	177
10 ,, ,, ,, +artificials*	309	185	182	242	229
Unmanured, - - - -	100	100	100	100	...

* Superphosphate of Lime, 6 cwts. Sulphate of Ammonia, 1¼ cwts. Sulphate of Potash, 1½ cwts.

The figures demonstrate clearly how much season influences the yields from the same manurial dressing, and though the results are not given in the above table, variation in the type of soil accounted for even greater differences in the yields.

The writer wishes to acknowledge his indebtedness to Mr. D. G. O'Brien, M.A., B.Sc., and Mr. D. N. M'Arthur, B.Sc., for assistance in making up the various tables and correcting the proof-sheets; and Mr. Peter Caldwell, who has done the greater part of the analytical work. He also wishes to express his thanks for assistance to former members of the Chemistry Department.

MONTHLY RAINFALL (IN INCHES) REGISTERED AT HOLMES FARM, KILMARNOCK, 1901-1913.

Month.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912	1913.	Average.
January, -	2·25	4·45	7 76	3·86	3·13	3·47	2·12	5·15	4·72	3·25	2·89	2·14	3·01	3·71
February, -	2·35	0·96	4·44	2·89	3·08	2·67	2·89	2·93	3·22	4·85	6·18	2·19	1·92	3·12
March, -	2·50	3·63	7·22	2·00	4·21	2·72	3·92	4·06	1·62	1·69	1·41	4·88	3 72	3·35
April, - -	3·80	1·03	1·41	4·45	2·52	1·35	2·71	1·97	4·05	2·89	2·68	1·98	2·35	2·55
May, - -	1·55	2·30	3·76	2·64	1·97	4·52	3·34	2·62	2·39	2·11	2·35	1·16	2·81	2·58
June, - -	2·77	1·49	2·82	1·28	1·55	1·06	3·00	2·62	3·07	1·45	2·09	3·58	2·65	2·26
July, - -	1·84	3·26	3·50	3·93	3·26	2·85	2·35	2·81	4·76	3·23	2·47	2·29	1·48	2·93
August, -	5·38	2·92	7·06	5·61	4·23	4·91	4·05	4·00	3·49	7·19	2 53	2·96	1·52	4·29
September, -	3·55	2·98	3·29	4·34	4·18	1·70	1·26	5·09	2·12	2·07	2·02	2·65	2·42	2·89
October, -	5·06	2·08	8·50	2·08	3·45	5·57	6·17	0·97	4·69	2·37	2·69	3·64	1·91	3·79
November, -	4·70	2·19	3·48	3·46	3·10	3·66	3·66	3·52	2·55	3·31	4·08	3·56	4·88	3·55
December, -	4·68	3·82	4·25	3·00	3·82	4·53	4·88	3·86	4·23	3·54	4·62	5·73	4·90	4·30
Whole Year,	40·43	31·11	57·49	39·54	38·50	39·01	40·35	39·60	40·91	37·95	36·01	36·76	33·57	39·32

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REPORTS

ON

EXPERIMENTS ON THE FEEDING OF POULTRY, CHICKENS, AND DUCKLINGS;

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ON UTILISATION OF HONEY AND WAX;

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ON WOOD AND PLANT ASHES AS A SOURCE OF POTASH;

ON THE WEATHER AT KILMARNOCK.

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GLASGOW, 1916.

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NOTE OF ACKNOWLEDGMENT.

The Governors of the College have pleasure in expressing their indebtedness to farmers and others who gave facilities for the carrying out of certain of the experiments dealt with in this report, and who incurred much trouble, and not a little expense, in their careful supervision and execution.

Bulletin No. 66.

West of Scotland Agricultural College.

DEPARTMENT OF

POULTRY HUSBANDRY,

HOLMES, KILMARNOCK.

REPORT

ON

EXPERIMENTS on the FEEDING OF POULTRY and on the FEEDING OF CHICKENS AND DUCKLINGS conducted during 1913-14.

BY

AGNES KINROSS, N.D.D.,

Manageress of Poultry Department.

ROBERT ANDERSON, GLASGOW.

REPORT ON EXPERIMENTS ON THE FEEDING OF POULTRY AND ON THE FEEDING OF CHICKENS AND DUCKLINGS CONDUCTED DURING 1913-14.

By AGNES KINROSS, N.D.D.,

Manageress of Poultry Department.

The experiments described in this Report commenced on October 1st, 1913, and ended on September 30th, 1914. They consisted of three on poultry feeding, extending over twelve months, and three on the feeding of Chickens and table Ducklings, viz. :—

I.—With poultry kept on the Colony System.

II.—With poultry kept in a Fixed House, with run attached.

III.—With poultry kept on the Intensive System.

IV.—Feeding of Chickens from birth to a laying age.

V.—Feeding of table Chickens from birth to a marketable age.

VI.—Feeding of table Ducklings.

The results of the above experiments may be of some value to poultry-keepers at the present time, when it is important that every farmer, small holder, crofter, and cottager who can maintain a flock of fowls of any size should do so in order to increase the egg production and supplies of table poultry at home, and to make up for the decrease in imports from abroad. From information published, there is a total decrease in September of imported eggs from all countries of 66·37 per cent., compared with September, 1913. The average values for the whole imports of eggs for September,

1913, were 8s. 11½d., and for September, 1914, 11s. 2d. per great hundred (120). The advance is chiefly due to the stoppage of eggs from Russia and Germany. The total values for September, 1913, were £110,557, and for September, 1914, £381,351. For imported poultry the total decline for September, 1914, is 92·64 per cent., neither eggs nor poultry coming from Russia. The declared values for poultry are:—September, 1913, £17,156; September, 1914, £1,841. The poultry-keeper, therefore, will see for himself how desirable it is to increase the home supplies.

The three experiments on poultry feeding were intended not merely as a comparison, but also to show the cost and the returns in egg production from the three systems.

Experiment No. I.—Sixteen White Wyandotte pullets were kept in a portable house in the pasture field, where freshness of soil had an important bearing on the results obtained, no poultry having been there before. They were, however, entirely exposed to the weather from the south-west. The house was made of ⅞-inch tongued and grooved wood, open fronted, with a wooden floor, and mounted on sledge runners for moving. The dimensions of the house were as follows:—6 feet 6 inches in length, 8 feet 6 inches in width, height at front 6 feet 9 inches, sloping to 4 feet 6 inches at the back (illustrated in Poultry Bulletin No. 64).

The fowls were placed in the house on October 1st, 1913, and remained there until September 30th, 1914. The house was frequently moved over the pasture, and the fowls had full liberty regardless of the weather.

Feeding.—Throughout the period two meals per day were given. Soft warm food was fed early in the morning, and in the afternoon grain food was scattered amongst the litter, inside the house in winter, and on different parts of the field during summer.

The fowls consumed in twelve months 11 cwt. 42 lbs. 8 ounces meals and grains, being an average quantity per bird of 79 lbs. 10·5 ounces, or approximately 3·5 ounces per bird per day.

The nature and quantity of foods used were as follows:—

112	lbs.	bran.
196	„	thirds.
112	„	biscuit meal.
392	„	wheat.
392	„	Indian corn.
40½	„	fresh meat.
28	„	fish meal.
2	„	linseed (fed during moulting).
56	„	oyster shell.
30	„	flint grit.

The last two items are not included in the total quantity given above. In addition, 134 lbs. granulated peat moss was used as litter.

The grain food consisted of a mixture of wheat and Indian corn, rather more of the latter being given during winter, and rather more of the wheat during summer. The soft food consisted of—

Biscuit meal, ...	1 part by weight.
Bran, ...	1 „ „
Thirds, ...	2 parts by weight.
Fish meal or meat, ...	½ part by weight.

The biscuit meal, bran, and fish meal were thoroughly scalded with boiling water and dried off with the thirds.

During winter a small proportion of cut vegetables was added, the whole made into a fairly dry condition, and fed from a trough. A supply of grit and oyster shell in a hopper was always before the birds, and fresh water was supplied daily.

The total cost of the foods consumed during the twelve months was £5 2s. 8½d., including the cost of oyster-shell, grit, litter, and medicines used. The average cost of feeding per bird for the year was 6s. 5d., or 1·5d. per week per bird. Thus, each bird had to lay 55 eggs at an average

value of 1·5d. each to pay for the food she consumed. The total number of eggs laid throughout the year was 2,987, or an average per bird of 186·6.

The total money value of eggs laid was £17 13s. 7½d., the valuation being taken on the basis of the wholesale market in Kilmarnock. These results may be summarised thus :—

	Total for 16 birds.	Per bird.
Value of eggs laid in 12 months,	£17 13 7½	£1 2 1·2
Cost of food for 12 months, - -	5 2 8½	0 6 5·
Balance over cost of food, -	£12 10 11	0 15 8·2

Results of 12 Months' Laying.

	Eggs laid.		Eggs laid.
October, 1913, -	65	April, 1914, - -	335
November, ,, -	191	May, ,, - -	277
December, ,, -	313	June, ,, - -	211
January, 1914, -	336	July, ,, - -	244
February, ,, -	276	Aug., ,, - -	210
March, ,, -	328	Sept., ,, - -	201
		Total, - -	2,987

35 eggs were broken or unsaleable. 16·3 per cent. were under 2 ozs., or second-grade eggs.

Weights of Eggs Laid :—

	Cwts.	Lbs.	Ozs.
Total weight of A grade eggs (2 ozs. and over),	2	83	10
Total weight of B grade eggs (1½ to 2 ozs.), ...	0	45	12
Total minimum weight of eggs laid, ...	3	17	6
Note.—The minimum weight is taken in both grades respectively, *i.e.*, 2 ozs. for A grade and 1½ ozs. for B grade. Useless and unsaleable eggs are kept out.			
Total weight of food consumed, ...	11	42	8

AVERAGE COST AND VALUE OF 1 DOZEN EGGS :—

Weight of food consumed to produce 1 doz. eggs,	5·1 lbs.
Average value of 1 dozen eggs, ...	1s. 5·25d.
Cost of food to produce 1 dozen eggs, ...	0s. 5·01d.
Balance over cost of food, ...	1s. 0·24d.

Experiment No. II.—Eighteen White Wyandotte pullets were kept in a fixed scratching-shed house and grass run. The house used was 10 feet square, 7 feet 8 inches in height at front, sloping to 5 feet at back. It was made of slimmer material than the colony house, and very difficult to keep dry during the winter months, the wood being only $\frac{5}{8}$ inch in thickness. The birds were, therefore not nearly so comfortably housed as those in Lot I. The area of the run allowed was fully 25 square yards per bird, and it was always fresh. The birds were placed in their quarters on 1st October, 1913, and remained until 30th September, 1914. They were allowed free access to the grass run (illustrated in Bulletin 64).

Feeding.—Throughout the period three meals per day were given. A small proportion of soft warm food was fed first thing in the morning, about 1 oz. each of grain was given during the forenoon, and a greater quantity of grain given in the afternoon, scattered amongst the litter inside the house. This lot consumed in twelve months 13 cwts. 62 lbs. meals and grains, an average quantity of 84 lbs. 6 ozs. per bird per annum, or approximately 3·6 ozs. per bird per day.

The nature and quantity of the foods used were :—

102 lbs.	bran.
164 ,,	thirds.
140 ,,	biscuit meal.
392 ,,	wheat.
370 ,,	Indian corn
256 ,,	oats.
36 ,,	fresh meat.
56 ,,	fish meal.
2 ,,	linseed (used during moulting).

In addition, 60 lbs. oyster-shell, 36 lbs. flint grit, and 184 lbs. granulated peat moss litter were used.

The grain food consisted of a mixture of wheat, oats, and Indian corn, rather more of the latter being given during the winter than in summer. The soft warm food was prepared and fed in the same way as for No. I., but in addition to the cut vegetable food this lot had, during winter, green food hung up a short distance off the ground. Grit and oyster-shell were always before the birds, and fresh clean water supplied daily.

The total cost of the foods consumed during the twelve months was £6 7s. 5½d., including the cost of oyster-shell, grit, litter, and medicine used. The average cost of feeding per bird for the year was 7s. 0·9d., or 1·6d. per bird per week. Thus each bird had to lay 60·6 eggs at an average value of 1·4d. each to pay for the food consumed. The total number of eggs laid throughout the year was 2,848, an average per bird of 158·2.

Note.—A larger egg-yield should have been recorded. One bird was out of the pen ill for four months, and one bird died during the period as the result of an accident.

Tne total money value of eggs laid was £16 7s. 9¾d., the valuation being taken on the basis of the wholesale market in Kilmarnock.

The above results may be summarised as follows :—

	Total for 18 birds.	Per bird.
Value of eggs laid in 12 months,	£16 17 9¾	£0 18 9·2
Cost of food for 12 months, -	6 7 5½	0 7 0·9
Balance over cost of food, -	£10 10 4¼	£0 11 8·3

Result of 12 Months' Laying.

	Eggs laid.		Eggs laid.
October, 1913, -	197	April, 1914, - -	349
November, ,, -	178	May, ,, - -	293
December, ,, -	227	June, ,, - -	223
January, 1914, -	303	July, ,, - -	241
February, ,, -	241	Aug., ,, - -	168
March, ,, -	313	Sept., ,, -	115
		Total - -	2,848

28 eggs were broken or unsaleable. 8·8 per cent. were under 2 ozs., or second-grade eggs.

WEIGHTS OF EGGS LAID :—

	Cwts.	Lbs.	Ozs.
Total weight of A grade eggs (2 ozs. and over),	2	97	8
Total weight of B grade eggs ($1\frac{1}{2}$-2 ozs.), ...	0	23	11·5
Total minimum weight of eggs laid, ...	3	9	3·5

NOTE.—Weights calculated as in Experiment No. I.

	Cwts.	Lbs.
Total weight of food consumed, ...	13	62

AVERAGE COST AND VALUE OF 1 DOZEN EGGS :—

Weight of food consumed to produce 1 dozen eggs,	6·4 lbs.
Average value of 1 dozen eggs, ...	1s. 5·25d.
Cost of food to produce 1 dozen eggs, ...	0s. 6·5d.
Balance over cost of food, ...	10·75d.

Experiment No. III.—50 pullets—25 White Leghorns and 25 White Wyandottes—were kept on the intensive house system.

The house was 21 feet in length and 16 feet in width, strongly made of $\frac{7}{8}$-inch tongued and grooved wood, open fronted, and the floor prepared with dry earth and chaff as scratching material. The excrement was removed from the droppings-board daily. The house was divided into two parts, with 25 birds in each and a grass run for each section (illustrated in Bulletin 64).

The birds were confined almost entirely from October 1st until April, but during the warm weather it was found desirable to give them occasional outings, otherwise they would have suffered in health. The birds were placed in their quarters on October 1st, 1913, and remained there until September 30th, 1914.

Feeding.—Throughout the period a meal of soft warm food was given in the early morning, and at 9.30 a.m. the whole of

the grain for the day was placed in automatic feeders. The grain from the feeders was allowed to fall amongst the litter, and provided the exercise so necessary for the birds.

The food consumed in twelve months was 37 cwts. 100 lbs. 8 ozs. meals and grains, an average of 84 lbs. 14 ozs. per bird per annum, or approximately 3·7 ozs. per bird per day. The nature and quantity of foods used were :—

224	lbs.	bran.
336	,,	thirds.
308	,,	biscuit meal.
1,260	,,	wheat.
856	,,	Indian corn.
1,001	,,	oats.
145½	,,	fresh meat.
112	,,	fish meal.
2	,,	linseed (during moulting).

In addition, 336 lbs. oyster-shell, 154 lbs. flint grit, and 81 dozen cabbages were fed. The grain food consisted of wheat, oats, and Indian corn, the latter being given in smaller quantities. The soft warm food was prepared and fed in the same way as for Lots I. and II., but in addition to the cut vegetables amongst the soft food the birds had a large supply hung up throughout the whole season. Grit and oyster-shell were also supplied from hoppers, and fresh clean water given daily.

The total cost of the foods consumed during the twelve months was £19 18s. 5¾d., including the cost of oyster-shell, grit, vegetables, and medicines used. The average cost of feeding per bird for the year was 7s. 11·7d., or 1·8d. per week per bird. Thus, each bird had to lay 68·3 eggs, at an average value of 1·4d. to pay for the food consumed. The total number of eggs laid throughout the year was 7,445, an average of 148·9. The total money value of eggs laid was £43 15s. 5¼d., the valuation being taken on the same basis as for Lots I. and II.

The above results may be summarised as follows—

	Total for 50 birds.	Per bird.
Value of eggs laid in 12 months,	£43 15 5¼	£0 17 6·3
Cost of food for 12 months. - -	19 18 5¾	0 7 11·7
Balance over cost of food, -	£23 16 11½	£0 9 6·6

Result of 12 Months' Laying.

	Eggs laid		Eggs laid.
October, 1913. -	176	April, 1914, - -	982
November, ,, -	411	May, ,, - -	949
December, ,, -	480	June, ,, - -	743
January, 1914, -	521	July, ,, - -	725
February, ,, -	528	Aug., ,, - -	709
March, ,, -	774	Sept., ,, - -	447
		Total, - -	7,445

137 eggs were broken or unsaleable, while 11·5 per cent. were under 2 ozs., or second-grade eggs.

Weights of Eggs Laid:—

	Cwts.	Lbs.	Ozs.
Total weight of A grade eggs (2 ozs. and over),	7	23	8
Total weight of B grade eggs (1½-2 ozs.), ...	0	80	7
Total minimum weight of eggs laid, ...	7	103	15

Note.—Weights calculated on the same basis as above.

Total weight of food consumed, ...	37	100	8

Average Cost and Value of 1 doz. Eggs.

Weight of food consumed to produce 1 doz. eggs,	6·9 lbs.
Average value of 1 dozen eggs, ...	1s. 5·25d.
Cost of food to produce 1 dozen eggs, ...	0s. 7·85d.
Balance over cost of food, ...	0s. 9·40d.

It must be understood that the labour connected with intensive poultry-keeping is much greater than when birds are in field colonies or have access to a good grass run at any time.

Unless the excrement is removed daily, the atmosphere kept fresh, and the utmost cleanliness observed, this system could not possibly be successful. The reader should also note particularly that green vegetable food is an absolute necessity for the maintenance of good health, and that the poultry-keeper must look ahead to have a regular supply, as otherwise this system would not be so successful. The only occasion during the above test on which any bird showed a vicious habit, viz., egg-eating, was at a time when green food was scarce. This habit was easily broken off by allowing the birds out on the grass run for a day or two. It should also be noted that a very large quantity of oyster-shell was consumed per bird compared with that consumed by the birds kept on the other systems, those on the intensive system consuming 6·7 lbs. per bird, as against 3·5 lbs. per bird for those on the colony system. Old mortar and broken crockery, so often advocated as being sufficient for grit, could never replace oyster-shell. Moreover, crockery requires to be used with discretion, as the glaze contains lead, which might have poisonous effects.

The intensive method of poultry-keeping, carried on properly, is, however, of great value to those with limited space, but for the farmer nothing can beat the portable or colony system.

The prices of feeding stuffs have not been stated, as these fluctuated throughout the year, and the foods were bought periodically in small quantities.

At the present prices of feeding stuffs it will be impossible to feed a fowl for the low sum of 3s. 6d. to 4s. per annum, as is so often stated can be done. Poultry-keepers should, however, make use of waste materials, and farm poultry-keepers should utilise the crops of the farm. Potatoes may be cooked and added to the ration in limited quantities, and bran.

thirds, scrap meat, and a little oatmeal may be used along with them. Indian meal or barley meal should not be used alone with potatoes.

Turnips may also be cooked or fed raw, and all other vegetables available freely used, which will give bulk, keep up the health of the fowls, and lessen the quantity of meals required. Soured or buttermilk may be given, either mixed with the meals or to drink. This supplies flesh-forming material, and, when used, meat is not necessary. A fowl requires to be well nourished and well cared for to obtain good results.

Experiment No. IV.—The Feeding of Chickens from Birth to a Laying Age.

For the first twelve weeks two methods of treatment were adopted. 32 White Wyandotte chickens, hatched from the same pen of birds and in the same incubator, were placed in each lot. The experiment began on 26th February, 1914, and was continued until September 30th, 1914—a period of 31 weeks.

Lot 1 was fed on soft food and seeds in alternate meals. The following are the results during the first 12 weeks.

Average weight per chicken when hatched,					1·3 oz.
"	"	end of 1st week,		-	1·8 "
"	"	" 2nd	"		2·1 "
"	"	" 3rd	"	-	3·4 "
"	"	" 4th	"	-	4·8 "
"	"	" 5th	"	-	7·2 "
"	"	" 6th	"	-	10·03 "
"	"	" 7th	"	-	14·45 "
"	"	" 8th	"		1 lb. 5 "
"	"	" 9th	"	-	1 " 7 "
"	"	" 10th	"	-	1 " 10 "
"	"	" 11th	"	-	1 " 14 "
"	"	" 12th	"	-	1 " 14¼ "

The chicks consumed during this period—

17½	lbs.	fine seed mixture.
35	,,	second-grade mixture.
21	,,	biscuit meal.
4	,,	pinhead oatmeal.
13	,,	bran.
23½	,,	thirds.
6½	,,	fish meal.
5	,,	fresh meat.
16	,,	Indian meal.
3	,,	grit.

Total quantity :—141½ lbs. food and 3 lbs. grit for 12 weeks. Total cost for 30 chickens, 16s. 4½d. Total cost for 1 chicken, 6½d. for 12 weeks.

Lot 2 was fed on seeds only. The following are the results during the first 12 weeks :—

Average weight per chicken when hatched,				1·3	oz.
,,	,,	end of 1st week,	-	1·8	,,
,,	,,	,, 2nd ,,	-	2·1	,,
,,	,,	,, 3rd ,,	-	3·3	,,
,,	,,	,, 4th ,,	-	5·03	,,
,,	,,	,, 5th ,,	-	9·31	,,
,,	,,	,, 6th ,,	-	11·84	,,
,,	,,	,, 7th ,,	1 lb.	·02	,,
,,	,,	,, 8th ,,	1 ,,	4	,,
,,	,,	,, 9th ,,	1 ,,	8½	,,
,,	,,	,, 10th ,,	1 ,,	10	,,
,,	,,	,, 11th ,,	2 ,,		
,,	,,	,, 12th ,,	2 ,,	½	,,

The chicks consumed during the period—

45½	lbs.	fine seed mixture.
98	,,	second-grade mixture.
5	,,	fresh meat.
18	,,	bran (fed dry from a hopper).
3	,,	grit.

Total quantity—166½ lbs. food and 3 lbs. grit.
Total cost for 28 chickens, 18s. 8d. for 12 weeks.
Total cost per chicken, 8d. for 12 weeks.

From the above it will be seen that it is rather more costly to feed on seeds only. Although the labour connected with the preparation of the food is less, in the hands of a careless feeder much greater waste would follow, as the seeds are thrown amongst litter to give exercise to the birds.

The undernoted were the seed mixtures used :—

Fine seed mixture—

5 parts wheat.
2 „ Indian corn.
2 „ rice.
3 „ pinhead oatmeal.
3 „ canary seed.
1 part hemp.

Second-grade seed mixture—

6 parts wheat.
2 „ Indian corn.
3 „ pinhead oatmeal.
4 „ dari.
1 part hemp.

Coarse seed mixture—

8 parts wheat.
4 „ Indian corn.
3 „ dari.
1 part hemp.

At the end of the 12th week, *i.e.*, on May 21st, the cockerels in both lots were removed, the pullets, 27 in number, were placed together, and the experiment continued, to find the total cost of feeding the pullets to a laying age. From the 13th week, *i.e.*, from May 22nd to the end of the 31st week, which brought them to the 30th of September, when they were placed in their winter quarters and the experiment finished,

the food consumed was as follows:—

84 lbs. coarse seed mixture.
169 ,, wheat.
127 ,, oats.
125½ ,, bran (hopper fed).
17 ,, fish meal.
48 ,, oatmeal.
3 ,, linseed.
16½ ,, grit and oyster-shell.

Total quantity—607½ lbs. food and 16½ lbs. grit.

Total cost for 19 weeks, £2 7s. 8¼d.

Total cost for 19 weeks per bird, approximately 1s. 9·1d.

The average cost for the whole period of 31 weeks was 2s. 4·9d. each. This sum is for food only; it does not include cost of eggs for hatching purposes, incubation, oil for brooders, labour, and litter.

The above experiment will show the poultry-keeper how necessary it is to economise in rearing, to prevent waste, and also to have the cockerels removed early and disposed of at a marketable age. 116 eggs were laid during August, and 149 in September; total, 256 eggs, value £1 10s. 10d. Since then several of these early-laying pullets have moulted and ceased laying.

The bulk of the food given during the final period, *i.e.*, from 13th to 31st week, was in the form of grain, and therefore nearly all the time they had dry feeding.

Experiment No. V.—Feeding of Table Chickens from Birth to a Marketable Age. Two methods adopted.

Lot 1.—36 chickens—Indian Game-Faverolle Crosses—were fed from birth on soft food only.

They consumed in 14 weeks—

75¾ lbs. bran.
43½ ,, biscuit meal.
65¾ ,, oatmeal.
73¼ ,, thirds.
16 ,, fish meal.
13 ,, Indian meal.

Total quantity—292¼ lbs. meals and 10 lbs. grit. Total cost

at 14 weeks old, £1 7s. 9¾d., or ¾d. per chicken per week. Average weight per chicken at 14 weeks, 3 lbs. 5 ozs. Five chickens died during this period, leaving 31, consisting of 11 cockerels and 20 pullets. These were placed into the fattening coops for a period of three weeks to be fattened before killing. They consumed during fattening—134 lbs. ground oats; 18 gallons soured milk, reckoned at 1d. per gallon; 3½ lbs. of fat, at 6d. per lb. The fat was melted and mixed with the food towards the latter end of the fattening period. The soured milk was used instead of water to mix the ground oats to a proper feeding consistency.

The total cost of feeding was 19s. 0¾d., or 7¼d. per bird for three weeks, making the total cost for the whole period of 17 weeks 1s. 6·4d. per bird. Average weight when put up for fattening, 3 lbs. 4¾ ozs. Average weight at the end of the period, 4 lbs. 9¾ ozs. Average gain, 1 lb. 5 ozs.

The individual weights are given below :—

20 Pullets.

Before Fattening.	After Fattening.
2½ lbs.	4½ lbs.
3 "	4½ "
2½ "	4½ "
3 "	4¼ "
4 "	5 "
3 "	3¾ "
3 "	4¼ "
3 "	5½ "
3 "	4¾ "
4 "	4¾ "
3 "	4¼ "
3 "	3¼ "
3 "	4¼ "
3 "	4¼ "
3 "	4¼ "
3 "	3¾ "
3 "	4¾ "
3½ "	4¼ "
3 "	4¼ "
3 "	4¾ "

11 Cockerels.

Before Fattening.	After Fattening.
$3\frac{1}{2}$ lbs.	5 lbs.
$3\frac{1}{2}$ "	$4\frac{3}{4}$ "
$4\frac{1}{2}$ "	$5\frac{1}{4}$ "
$3\frac{1}{2}$ "	$4\frac{3}{4}$ "
4 "	$5\frac{1}{4}$ "
$3\frac{1}{2}$ "	$5\frac{1}{4}$ "
$4\frac{1}{2}$ "	$5\frac{1}{4}$ "
3 "	$4\frac{1}{2}$ "
$3\frac{1}{2}$ "	5 "
3 "	$5\frac{1}{4}$ "
$3\frac{1}{2}$ "	$5\frac{1}{2}$ "
Total, $101\frac{1}{2}$ lbs.	142 lbs. 12 ozs.

Average gain after fattening, 1 lb. 5 ozs.

Lot 2.—36 chickens—Indian Game-Faverolle Crosses—were fed from birth on soft food and seeds alternately. The food consumed in 14 weeks was—

44 lbs.	bran.
31 ,,	biscuit meal.
27 ,,	oatmeal.
25 ,,	thirds.
28 ,,	Indian meal.
5 ,,	fish meal.
14 ,,	meat meal.
15 ,,	cooked seed mixture.
12 ,,	fine seed mixture.
41 ,,	second-grade mixture.
30 ,,	coarse-grade mixture.
14 ,,	wheat.
14 ,,	oats.
14 ,,	dari.
5 ,,	grit.

Total quantity, 314 lbs. food and 5 lbs. grit.

Total cost, £1 11s. 6d., or approximately $\frac{3}{4}$d. per chicken per week.

The average weight of 33 chickens at the end of 14 weeks was 2 lbs. 4¾ ozs., being on an average 1 lb. in weight less than Lot No. 1.

They were kept in the free run for three weeks longer, and they consumed in that time 161 lbs. meals and grains, as follows :—

32	lbs.	dari.
32	,,	oats.
32	,,	wheat.
11	,,	meat meal.
24	,,	thirds.
30	,,	bran.

The cost for three weeks was 10s. 11½d.

The total cost for the period of 17 weeks amounted to £2 4s. 5½d., or 1s. 4·1d. per chicken. 6 pullets were sold alive, leaving 27 to be placed in the fattening pens. The average weight at 17 weeks was 4 lbs. 1 oz.

During the fattening period they consumed 60 lbs. ground oats; 15 gallons soured milk, at 1d. per gallon; 2 lbs. fat, at 6d. per lb.

The total cost during the fattening period was 8s. 5d.

The total cost during the fattening period was 3¾d. per chicken.

Average weight when put up for fattening,		4 lbs.	1 oz.
Average weight at end of period, - - -		4 ,,	12 ,,
Average gain, - - - - - -		0 ,,	11 ,,

At the end of 14 weeks the 32 chickens consisted of 22 pullets and 11 cockerels. When put up for fattening, at the end of 17 weeks, there were 11 cockerels and 16 pullets.

The average cost of rearing for 20 weeks was therefore 1s. 7·9d. per chicken.

The individual weights before and after fattening were as follows :—

11 Cockerels.

Before Fattening.	After Fattening.
$5\frac{3}{4}$ lbs.	6 lbs.
6 "	$6\frac{1}{4}$ "
$5\frac{1}{4}$ "	$5\frac{3}{4}$ "
$5\frac{1}{4}$ "	$5\frac{1}{4}$ "
$5\frac{3}{4}$ "	$6\frac{1}{4}$ "
$5\frac{1}{4}$ "	$6\frac{1}{4}$ "
$4\frac{1}{4}$ "	$4\frac{2}{4}$ "
$4\frac{1}{4}$ "	$4\frac{3}{4}$ "
$4\frac{1}{4}$ "	$5\frac{1}{4}$ "
$5\frac{1}{4}$ "	$5\frac{1}{4}$ "
$4\frac{1}{4}$ "	5 "

16 Pullets.

$3\frac{1}{4}$ "	4 "
$3\frac{3}{4}$ "	$4\frac{3}{4}$ "
$3\frac{3}{4}$ "	$4\frac{1}{4}$ "
$4\frac{1}{4}$ "	$4\frac{3}{4}$ "
$3\frac{1}{4}$ "	$5\frac{1}{4}$ "
$3\frac{1}{4}$ "	$3\frac{3}{4}$ "
$3\frac{3}{4}$ "	4 "
$3\frac{3}{4}$ "	$4\frac{1}{4}$ "
$3\frac{1}{4}$ "	$4\frac{1}{4}$ "
$4\frac{1}{4}$ "	$5\frac{1}{4}$ "
3 "	$3\frac{3}{4}$ "
$3\frac{1}{4}$ "	$4\frac{1}{4}$ "
$3\frac{1}{4}$ "	$4\frac{1}{4}$ "
$3\frac{1}{4}$ "	$4\frac{1}{4}$ "
3 "	$3\frac{1}{2}$ "
$3\frac{1}{4}$ "	4 "
Total weight, 111 lbs.	119 lbs. 4 ozs.

This experiment was intended as a comparison of two different methods of fattening chickens, and also to show that,

if any appreciable increase of weight is to be obtained and fattening to be really profitable, chickens weighing, when placed in the fattening pens, from 2½ to 3 lbs., make the greatest economic gain.

Experiments with fattening chickens have been conducted steadily throughout the season, and in every one this fact has been noticeable. Any poultry-keeper, therefore, who contemplates fattening off surplus cockerels will do so with the greatest economic gain and profit by placing the birds in the fattening pens whenever they are 2½ to 3 lbs. in weight; in other words, a chicken which has been well reared should be ready for fattening at 12 to 14 weeks old, and if taken then they can be fattened and sold quite profitably.

Experiment No. VI.—Feeding of Ducklings for Market.

The results given below compare favourably with those from a similar experiment conducted last season, and which are given in Bulletin 64.

Cost of feeding 12 Aylesbury ducklings for 10 weeks :—

Food consumed during that period—

9	lbs.	second-grade seed mixture.
23	,,	coarse seed mixture.
16½	,,	biscuit meal.
34	,,	6 ozs. ground oats.
12	,,	fish meal.
7	,,	Indian meal.
33	,,	thirds.
46	,,	bran.

Total quantity—180½ lbs. meals and grains, and 21 lbs. grit. Total cost for 12 ducklings was 16s. 6¾d., and the cost of rearing and feeding one duckling for 10 weeks was 1s. 6d. (The average cost is for 11 ducklings, one having died one week after the experiment was begun.) This amount does not include cost of eggs for incubation, cost of hatching, and labour. To be at all profitable, it is neces-

sary to have them ready for market from 8 to 10 weeks old. Otherwise, they will require to be kept for a few weeks longer, as about this age they lose their duckling feathers, and the food consumed will be largely used for the production of their new adult plumage. Ducklings are also at all times heavy feeders.

It is rarely possible to obtain more than 2s. to 2s. 6d. wholesale for a duckling on any market in Scotland, so that if they are not sold at the above-mentioned age they will be kept at a loss to the producer. A good Aylesbury duckling at 10 weeks should weigh not less than 4½ lbs.

It would be advisable to hatch them out in small lots, with an interval between each lot so that too many would not be ready for selling at one time. In order to obtain the best results, ducklings intended for market should be confined to small areas for the greater part of the 10 weeks, say from the third week onwards. If they have too much liberty, exercise, and swimming-water, they will not put on flesh to the same extent; further, when they are allowed to roam and to mix with other chickens and fowls, they will do much harm by fouling the ground and eating the food of the other stock, which will suffer at the expense of the ducklings. The flesh will also be harder and stronger in flavour than when they are confined.

Even where wet or marshy land is available, ducklings cannot be got into a condition fit for sale without good feeding.

The above results may be of some use to poultry-keepers, as the rearing of table ducklings is being encouraged by the Board of Agriculture for Scotland in their Scheme for Poultry Breeding for 1915. The consuming public in Scotland is very small, ducklings being looked upon more as a luxury than as an economic addition to the culinary department, and this is true when they are compared with well-grown chickens obtained for the same money.

BULLETIN No. 67.

West of Scotland Agricultural College.

REPORT

ON

CATTLE FEEDING EXPERIMENTS

CONDUCTED AT

CRICHTON FARM, DUMFRIES,

IN

1911-12, 1912-13, 1913-14, and 1914-15,

BY

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GLASGOW, 1915.

ROBERT ANDERSON, GLASGOW.

Cattle Feeding Experiments Conducted at Crichton Farm, Dumfries, in 1911-12, 1912-13, 1913-14, and 1914-15.

INTRODUCTORY.

It is well known that the return in cattle feeding is very variable, as it depends upon such all-important factors as the following :—

The Class of Cattle employed.—The finest beef breeds of cattle in the world are to be found in Britain, but in spite of that there is room for great improvement in commercial beef cattle. Animals differ very widely in the way they respond to feeding, and what the feeder requires is a class of cattle with fattening propensities well developed, as no factor plays a more important part than that.

The Cost of the Cattle to the Feeder at the time they are put up to Fatten.—This may be the actual cost of rearing the young stock, or may in turn merely represent their purchase price in the store market. The return from cattle feeding is generally greatest when the stock have been reared by the feeder, though the facilities for rearing cattle on certain farms and the state of the store market at times may be such that the cost of rearing is actually greater than the purchase price of equivalent stores would have been.

The State of the Market when the Fattening Process is complete.—Over this all-important factor the feeder as an individual has little or no control. He is at the mercy of the law of supply and demand, and an unfavourable market at the time the cattle are ready for disposal greatly lessens the chance of obtaining a satisfactory return. Even the holding up of the cattle until the market improves is a course of

doubtful policy. The feeder may obtain a higher price, but it must be remembered that the actual daily or weekly gain in live weight made by cattle that are prime, or nearly so, is very small, and its value in itself very far short of the cost of producing it. Hence even the slightly enhanced value per cwt. that can be expected may not be sufficient to make this method profitable, unless a considerable improvement in the market takes place.

The value attached to the resulting Farmyard Manure, and the attention bestowed on the making and utilisation thereof.—Cattle that are house-fed for about four months and well supplied with bedding may leave anything from four to six tons of farmyard manure. The quantity produced will vary according to the ration, the amount and nature of the litter supplied, and the method of housing adopted. At 7s. 6d. per ton, the approximate value of the manure would be 30s. to 45s. for each animal house-fed for four months. In some districts little or no return is expected beyond the farmyard manure, but the writer cannot believe that such a return is sufficiently adequate to justify cattle feeding unless in somewhat exceptional circumstances.

Fattening cattle give rise to specially rich manure, particularly if such highly nitrogenous feeding stuffs as decorticated cotton cake, soya cake, linseed cake, bean meal, or other similar feeding stuffs bulk largely in the ration. Unfortunately, the manure, being specially rich, is liable to all the greater loss, and due precaution should be taken to avoid loss.

The loss is always least when the cattle are put up in loose boxes—so constructed that no escape of liquid manure is possible—and where the manure is allowed to accumulate under the feet of the cattle, and sufficient litter of an absorbent nature added from time to time to take up all the liquid manure and keep the animals clean and comfortable.

The Supply of Roots and Fodder available.—Abundant supplies of roots and fodder (especially turnips and straw) contribute greatly to successful cattle feeding. In fact, these are amongst the main factors in determining the number of

cattle that can be dealt with. When roots are plentiful and straw somewhat scarce, it is wise to eke out the fodder supply by using peat moss as litter, thus leaving all the straw for fodder. The peat moss will absorb about three times as much moisture as the same weight of straw would do, and provided a certain amount of straw is added from time to time to make the peat moss stand more trampling, every ton of peat moss used as litter will set free about three tons of straw for fodder. Cattle getting a liberal supply of roots will eat even inferior straw quite readily, and do well on it.

The Concentrated Feeding Stuffs employed and the System of Feeding and General Management adopted.—The most profitable system of cattle feeding demands the selection of concentrated feeding stuffs of such a nature as will enable the feeder to utilise the home-grown produce to the fullest advantage. Naturally the feeder wishes to get the best possible return for every ton of turnips or fodder consumed, but he sometimes overlooks the fact that this can only be done by the selection of feeding stuffs which will best make up the deficiencies in home-grown produce. Home-grown produce is deficient in protein or albuminoids, but specially rich in carbohydrate material, hence the feeder, in order to take the most out of the home produce, requires to purchase concentrated foods rich in protein or albuminoid matter. For example, one ton of decorticated cotton cake or one ton of soya bean cake will be of infinitely greater value than similar amounts of bran or maize meal for feeding along with roots and straw. Decorticated cotton cake and soya bean cake contain about 34 per cent. of digestible protein. Bran and maize meal, on the other hand, usually contain respectively 10 per cent. and 7 per cent. of digestible protein, and while valuable feeding stuffs in themselves, they are not specially adapted for making up deficiencies in home-grown produce.

The system of housing is, of course, determined by the nature of the farm buildings; but cattle, as a rule, make best progress when they are put up singly or in pairs in small loose boxes. For rapid fattening this system is much better than the common cattle court system, in which a large number of animals are fed together. It is also better than stall-

feeding, especially if the feeding period is a fairly long one; if the feeding period is short, cattle will do quite well tied up in stalls, but it must be remembered that this system makes conservation of the farmyard manure, and especially of the liquid manure, a more difficult problem.

Whatever system of housing is adopted, all unnecessary disturbance of the cattle should be avoided, as they thrive best when least disturbed. For very rapid fattening, a cattle shed or byre that is not too well lighted has a slight advantage, in that it tends to produce greater restfulness.

Attention to practical details, such as regularity in feeding, careful measurement of the food, cleanliness of the feeding troughs, &c., are also very important factors, so much so that it can with truth be said " the eye of the master fattens the cattle."

OBJECTS OF EXPERIMENT.

The experiments under consideration were undertaken in order to determine the relative values—in the production of beef—of such well-known and widely-used feeding stuffs as decorticated cotton cake, soya bean cake, and a mixture of linseed cake and undecorticated cotton cake when fed along with home-grown farm produce, and incidentally to ascertain what return can reasonably be expected from home-grown farm produce when so utilised. Apart from the cakes to be tested, the ration was made up of oats (crushed), hay, straw, and turnips, all of which were produced on the farm.

METHOD OF CONDUCTING EXPERIMENT.

The first experiment was carried out in the winter of 1911-12, but as only a limited number of cattle were available, it was repeated for confirmation of the results in 1912-13, and again in 1913-14.

The method of procedure was the same in each of these years. The cattle used for the experiment were two-year-old blue-grey and black bullocks of very uniform type—a factor which contributes in no small degree to the reliability of the results.

Each year, out of a group of 17 cattle that were available, 12 were selected after a carefully-conducted preliminary experiment with a ration in which all the foods to be employed in the experiment proper were represented. This preliminary trial served an exceedingly useful purpose, as not only did it to some extent accustom the animals to the foods on which they were afterwards to be fed, but what was even more important, it rendered possible the exclusion of any unsatisfactory animal, and gave an opportunity of selecting groups of animals as nearly as possible identical in live weight and in individuality, as far as the latter could be judged by the individual live weight gains made during the preliminary trials.

The experiments proper lasted for a period of 70 days in each of the years, and during each experiment the cattle were weighed every 14 days, the time of weighing being always between 11 a.m. and 12 noon, and just prior to the giving of the mid-day meal. To all the animals under experiment the following daily basal ration was fed :—

4 lbs. crushed oats (this was increased to 4½ lbs. at the end of four weeks).
4 lbs. ryegrass hay.
72 lbs. swedes.
Straw and water *ad lib.*

On an average about 12 lbs. of straw was consumed daily by each animal.

The cattle were put up in pairs in pens (see illustration) of an ideal type, provided with suitable feeding-boxes, a rack for the long fodder, and a constant supply of water. The pens are 14½ feet long by 13½ feet broad, with a wide gangway on the long side and a door in the one directly opposite. The floor is of concrete, and sunk 1½ feet below the level of the gangway. The pens are separated from each other and from the gangway by strong iron tubular railings. Every pen is provided with two 4-foot iron troughs on the gangway side. These troughs are divided into two compartments—a 3-foot compartment for food, and a 1-foot compartment for water. There is a space of 1 foot between the outside wooden

door of each pen and an inner iron gate, and this forms an admirable rack for fodder. It will be seen that the construction is such that the attendant never requires to enter the pens except for the purpose of putting down fresh litter or grooming the cattle, and such an arrangement has many advantages.

After the preliminary trial each year the 12 cattle selected were divided into three uniform groups, with 4 animals in each. For the sake of distinction, these were designated Lot A, Lot B, and Lot C, and the animals were numbered consecutively 1 to 12. The average weight of the cattle in the different lots at the commencement of the experiment in each year was as follows :—

	Lot A.			Lot B.			Lot C.		
Season.	Cwts.	qrs.	lbs.	Cwts.	qrs.	lbs.	Cwts.	qrs.	lbs.
1911-12, ...	9	3	11	9	3	14	9	3	13
1912-13, ...	9	2	9	9	2	4	9	2	18
1913-14, ...	10	1	25	10	1	22½	10	1	1

Experimental Ration.—In addition to the basal ration already referred to, each animal in Lot A received daily 4 lbs. decorticated cotton cake (increased after four weeks to 4½ lbs. daily); each animal in Lot B, 4 lbs. soya bean cake (increased after four weeks to 4½ lbs.); and each animal in Lot C, 3 lbs. undecorticated cotton cake and 2 lbs. linseed cake (increased after four weeks to 2½ lbs. linseed cake).

The average live-weight increase of the different lots in each of the three years was as follows :—

Lot A.

	Average live weight at beginning of experiment.			Average live weight at end of experiment.			Average increase.
Season.	Cwts.	qrs.	lbs.	Cwts.	qrs.	lbs.	Lbs.
1911-12, ...	9	3	11	11	0	27	156*
1912-13, ...	9	2	9	10	3	24	155
1913-14, ...	10	1	25	11	3	26	169

Average increase, 160 lbs., or 16 lbs. per head per week.

* One animal in this lot went slightly off its food towards the end of the experimental period, and there is good reason for believing that but for this the average increase in 1911-12 would have been considerably greater.

Lot B.

Season.	Average live weight at beginning of experiment. Cwts.	qrs.	lbs.	Average live weight at end of experiment. Cwts.	qrs.	lbs.	Average increase. Lbs.
1911-12, ...	9	3	14	11	1	14	168
1912-13, ...	9	2	4	10	2	1	109*
1913-14, ...	10	1	23	11	3	7	152

Average increase, 143 lbs., or 14·3 lbs. per head per week.

Lot C.

Season.	Average live weight at beginning of experiment. Cwts.	qrs.	lbs.	Average live weight at end of experiment. Cwts.	qrs.	lbs.	Average increase. Lbs.
1911-12, ...	9	3	13	11	0	10	137
1912-13, ...	9	2	18	10	2	20	114
1913-14, ...	10	1	1	11	2	7	146

Average increase, 132 lbs., or 13·2 lbs. per head per week.

SUMMARY OF LIVE-WEIGHT GAINS AND COST AT WHICH OBTAINED.

Average live-weight increase per head from the 12 animals in :—

Lot A, ...	160 lbs.
Lot B, ...	143 ,,
Lot C, ...	132 ,,

Average weekly increase per animal :—

Lot A, ...	16 lbs.
Lot B, ...	14·3 ,,
Lot C, ...	13·2 ,,

The average prices of the different feeding stuffs broken ready for use and delivered at the farm were as follows :—

Decorticated Cotton Cake, ...	£9 10 0 per ton.
Soya Bean Cake, ...	8 10 0 ,,
Linseed Cake, ...	10 0 0 ,,
Undecorticated Cotton Cake,...	6 15 0 ,,

* One animal in this lot made a rather disappointing gain in the first few weeks of the experiment, otherwise the average in 1912-13 would have been better.

The amount of cake consumed by each animal in the different lots and the cost thereof at the prices already given is stated below :—

Lot.	Cake fed.	Amount consumed per animal. Cwt.	qrs.	lbs.	Cost of cake per animal.
A.	Decorticated Cotton Cake, ...	2	2	21	25s. 6½d.
B.	Soya Bean Cake, ...	2	2	21	22s. 10d.
C.	Undecorticated Cotton Cake,	1	3	14	27s. 0½d.
	Linseed Cake, ...	1	1	21	

If we neglect for the moment the basal part of the ration and take into account purchased cakes only, we will find that the cost per lb. live-weight increase for the different lots is as follows :—

	Average live weight increase.	Cost of cake consumed.	Cost per lb. increase.
Lot A, ...	160 lbs.	25s. 6½d.	1·91d.
Lot B, ...	143 ,,	22s. 10d.	1·91d.
Lot C, ...	132 ,,	27s. 0½d.	2·45d.

It will be readily apparent that decorticated cotton cake and soya cake both proved decidedly superior to the mixture of linseed cake and undecorticated cotton cake, even in spite of the fact that 1 lb. additional of the mixture was fed. There is, therefore, not the slightest doubt but what decorticated cotton cake and soya bean cake, when fed along with the basal ration already described, are each superior for fattening purposes to a mixture of linseed cake and undecorticated cotton cake.

The superiority of decorticated cotton cake over soya bean cake is, however, not so easily apparent. The cost per lb. live-weight increase proved to be the same from these two feeding stuffs, namely, 1·91d. per lb., when nothing was considered but the cost of the cake. The decorticated cotton cake, however, gave an average increase of 16 lbs. per animal per week (2·3 lbs. per day); the soya bean cake an average increase of only 14·3 lbs. per animal per week (2·04 lbs. per day). On the other hand, the decorticated cotton cake was the more costly cake, the price per ton being £9 10s., while the price of the soya cake was £8 10s. per ton. There is, there-

fore, little difference in the results from these two cakes. What difference there is, when the cost of the whole ration is considered, is in favour of decorticated cotton cake, but it is scarcely sufficient to cover experimental errors.

It is well, however, to point out here that the animals getting decorticated cotton cake made quite as much gain in nine weeks as those getting soya cake made in ten weeks; while the gain they made in eight weeks was similar to that made by the animals getting linseed cake and undecorticated cotton cake in the ten weeks, and when roots and straw are scarce and rapid fattening needs to be aimed at, such a result is of considerable importance.

The cattle were all in very good condition by the end of the preliminary trial conducted each year, and at the end of the ten weeks' experiment several of them, particularly in Lot A, and in a slightly less degree in Lot B, were ready for the fat market. At Crichton Farm, however, the cattle are not marketed, but slaughtered as required to supply the needs of the Crichton Institution.

Since there are no market prices to fall back on as a basis of the financial aspect of the experiment, that is perhaps best wrought out by applying what were considered by practical men fair values per cwt. live weight for the different lots at the beginning and end of the experiment.

At the beginning of the experiment the cattle were arranged in uniform groups, and 38s. per cwt. live weight may be taken as representing the value of each lot or group at that time.

At the end of the experiment the groups were not quite so uniform, and naturally those groups making the largest daily or weekly gain were nearest the prime condition, and consequently worth a little more per cwt. live weight.

The cattle getting decorticated cotton cake did best, and were considered worth on the average 42s. per cwt. live weight at the end of the experiments.

The soya bean cake lots were not much behind, and were valued at 41s. 6d. per cwt. live weight.

The linseed cake and undecorticated cotton cake lots were the poorest, and were valued at 41s. per cwt. live weight.

Applying these comparative values we get the results tabulated below :—

LOT A. DECORTICATED COTTON CAKE.

Average live weight at beginning of experiment.	Value at 38s. per cwt.	Average live weight at end of experiment.	Value at 42s. per cwt.	Increase in value.
Cwt. qrs. lbs.	£ s. d.	Cwt. qrs. lbs.	£ s. d.	£ s. d.
9 3 24	18 18 8	11 1 16	23 18 6	4 19 10

The increase in value per animal is 99s. 10d. for the ten weeks, or, approximately, 10s. per week.

After deducting the cost of the cake consumed, this leaves a balance of 7s. 5d. per animal per week.

LOT B. SOYA BEAN CAKE.

Average live weight at beginning of experiment.	Value at 38s. per cwt.	Average live weight at end of experiment.	Value at 41s. 6d. per cwt.	Increase in value.
Cwt. qrs. lbs.	£ s. d.	Cwt. qrs. lbs.	£ s. d.	£ s. d.
9 3 23	18 18 4	11 0 26	23 6 2	4 7 10

The increase in value per animal is 87s. 10d. for the ten weeks, or 8s. 9½d. per week.

After deducting the cost of the cake consumed, this leaves a balance of 6s. 6d. per animal per week.

LOT C. UNDECORTICATED COTTON CAKE AND LINSEED CAKE.

Average live weight at beginning of experiment.	Value at 38s. per cwt.	Average live weight at end of experiment.	Value at 41s. per cwt.	Increase in value.
Cwt. qrs. lbs.	£ s. d.	Cwt. qrs. lbs.	£ s. d.	£ s. d.
9 3 20	18 17 4	11 0 12	22 15 4	3 18 0

The increase in value per animal is 78s. for the ten weeks, or 7s. 9½d. per week.

After deducting the cost of the cake consumed, this leaves a balance of 5s. 1d. per animal per week.

Average weekly increase in value per animal after cost of cake is deducted :—

Lot A. Decorticated Cotton Cake, ... 7s. 5d.
Lot B. Soya Bean Cake, ... 6s. 6d.
Lot C. Linseed Cake and Undecorticated Cotton Cake, ... 5s. 1d.

From this aspect of the results, decorticated cotton cake compared with soya cake is more profitable to the extent of 11d. per animal per week, or 9s. 2d. per animal over the experimental period.

Compared with the mixture of linseed cake and undecorticated cotton cake, decorticated cotton cake is more profitable to the extent of 2s. 4d. per animal per week, or 23s. 4d. per animal for the experimental period.

RETURN FROM FARM PRODUCE CONSUMED.

The return obtained from the utilisation of farm produce in the production of beef is a point that should always be carefully considered where cattle feeding is practised.

The consumption of the crop by the stock on the farm is a means of keeping up the supply of farmyard manure, but that, though very important, is not sufficient return, and the feeder must see that the farmyard manure is not produced at too great a cost.

In addition to the farmyard manure, the feeder should get from the utilisation of the farm produce in beef production a fair price per ton for the foods consumed. The feeding of the cattle is just a different way of marketing the farm produce. The crops, instead of being carted off the farm, are made to walk off the farm in the bodies of the animals. There is, however, this very important difference between the direct sale and removal of the farm produce and the disposal of it through the stock, when the crops are fed to the stock the greater part of the manurial value is left behind. That is not so when the crops are sold. The feeder should get at least a fair market price, less manurial value, for every ton of farm produce consumed.

In the case before us there is, according to the concentrated food used, a very great difference in the balance left to meet the cost of the home-grown farm produce consumed by the cattle.

Where decorticated cotton cake is used, the weekly balance after deducting the full cost of the cake, is 7s. 5d. per animal, but where the mixture of undecorticated cotton cake and linseed cake is used the balance is only 5s. 1d. per animal.

This means that in this particular experiment, where decorticated cotton cake was fed, the return for the home-grown farm produce consumed is 46 per cent. in advance of what it is when undecorticated cotton cake and linseed cake are used.

In the one case, namely, when undecorticated cotton cake and linseed cake was fed, there is a return equivalent only to—

7s. 6d. per ton of turnips consumed by the cattle,
2s. 6d. per bushel of oats,
50s. per ton of hay, and
30s. per ton of straw.

In the other, when decorticated cotton cake is fed, the return is, approximately, equivalent to—

10s. per ton of turnips consumed,
3s. 5d. per bushel of oats,
80s. per ton of hay, and
50s. per ton of straw.

It is readily apparent from this that the feeder gets an infinitely better return for the farm produce when it is fed along with decorticated cotton cake than when fed with undecorticated cotton cake and linseed cake.

When fed along with soya cake the return is not far behind that from decorticated cotton cake.

In arriving at these returns no account has been taken of the straw used as litter or of the cost of attendance. The value of the resulting farmyard manure is, however, sufficient to cover these charges.

COMPOSITION OF THE FEEDING STUFFS USED IN THE EXPERIMENT.

The cakes used were analysed each year, the oats in the first and second years, and the hay, straw, and turnips in the first year only. The results are tabulated below :—

1911-12.	Decorticated Cotton Cake. per cent.	Soya Bean Cake. per cent.	Linseed Cake. per cent.	Undecorticated Cotton Cake. per cent.
Protein (crude), ...	39·80	41·62	27·12	23·50
Oil, ...	16·10	6·03	7·56	4·96
Carbohydrates, ...	25·31	30·19	38·88	35·02
Fibre (crude), ...	2·80	5·23	8·40	19·16
Ash, ...	6·83	5·30	6·98	5·30
Moisture, ...	9·16	11·63	11·06	12·04

1912-13.	Decorticated Cotton Cake. per cent.	Soya Bean Cake. per cent.	Linseed Cake. per cent.	Undecorticated Cotton Cake. per cent.
Protein (crude), ...	38·87	40·31	25·87	24·56
Oil, ...	17·04	6·82	10·62	5·82
Carbohydrates, ...	23·76	28·26	34·95	29·93
Fibre (crude), ...	3·57	5·50	9·20	21·88
Ash, ...	6·82	5·75	6·40	5·17
Moisture, ...	9·94	13·36	12·96	12·64
1913-14.				
Protein (crude), ...	39·25	41·62	28·40	22·06
Oil, ...	11·32	4·92	9·18	4·70
Carbohydrates, ...	26·11	27·81	35·53	32·03
Fibre (crude), ...	3·66	4·66	7·52	22·28
Ash, ...	7·50	5·55	4·60	5·73
Moisture, ...	12·16	15·44	14·68	13·20

Oats.

	1911-12. Per cent.	1912-13. Per cent.
Protein (crude), ...	9·00	10·31
Oil, ...	5·39	6·38
Carbohydrates, ...	59·41	56·78
Fibre (crude), ...	8·82	9·12
Ash, ...	2·85	2·55
Moisture, ...	14·53	14·86

1911-12.	Hay.	Straw.	Turnips (Swedes).
Protein (crude), ...	8·00	2·00	1·10
Oil, ...	2·39	1·73	0·25
Carbohydrates, ...	41·04	43·06	6·70
Fibre (crude), ...	25·49	33·18	0·67
Ash, ...	4·75	2·99	0·41
Moisture, ...	18·33	17·04	89·50

INDIVIDUAL LIVE WEIGHTS AND INCREASES MADE DURING THE EXPERIMENT BY THE DIFFERENT LOTS.

Lot A. Decorticated Cotton Cake.

Season.	Bullock No.	Weight at beginning of experiment.			Weight at end of experiment.			Increases.
		Cwts.	qrs.	lbs.	Cwts.	qrs.	lbs.	Lbs.
1911-12, ...	1	10	3	12	12	0	0	128
	2	10	1	16	12	1	8	216
	3	9	3	24	11	2	2	174
	*4	8	0	20	9	0	12	104
1912-13, ...	1	10	2	18	12	0	12	162
	2	8	3	24	10	2	6	178
	3	9	3	14	10	3	20	118
	4	8	3	8	10	1	0	160
1913-14, ...	1	11	0	16	12	2	8	160
	2	11	1	27	12	3	24	165
	3	9	2	22	11	0	13	159
	4	9	2	8	11	1	0	188
Average, ...		9	3	24	11	1	16	160

* Animal No. 4, of 1911-12 experiment, went slightly off its food towards the end of the experiment, otherwise the live-weight gain would have been higher.

Lot B. Soya Bean Cake.

Season.	Bullock No.	Weight at beginning of experiment.			Weight at end of experiment.			Increases.
		Cwts.	qrs.	lbs.	Cwts.	qrs.	lbs.	Lbs.
1911-12, ...	1	10	2	16	12	0	0	152
	2	10	1	12	12	0	8	192
	3	9	2	12	11	1	26	210
	4	8	3	16	9	3	25	121
1912-13, ...	1	9	2	0	10	2	18	130
	2	9	1	22	10	1	10	100
	*3	9	0	20	9	3	0	64
	4	10	0	4	11	1	3	139
1913-14, ...	1	9	3	16	11	1	14	166
	2	11	1	4	12	3	20	184
	3	10	1	8	11	1	22	126
	4	10	1	8	11	2	8	140
Average, ...		9	3	23	11	0	26	143

*Animal No. 3, of 1912-13 experiment, made a poor gain in the early part of the experiment, but did better towards the end.

LOT C. LINSEED CAKE AND UNDECORTICATED COTTON CAKE.

Season.	Bullock No.	Weight at beginning of experiment. Cwts.	qrs.	lbs.	Weight at end of experiment. Cwts.	qrs.	lbs.	Increases. Lbs.
1911-12, ...	1	8	1	10	9	0	23	97
	2	10	1	16	12	0	9	189
	3	10	2	13	11	2	22	121
	4	10	0	14	11	1	13	139
1912-13, ...	1	10	1	17	11	1	20	115
	2	10	0	4	11	0	22	130
	3	9	2	5	10	1	18	97
	4	8	2	18	9	2	19	113
1913-14, ...	1	10	2	8	11	3	16	148
	2	11	0	5	12	2	0	165
	3	9	2	20	10	3	18	138
	4	9	3	0	10	3	20	130
Average, ...		9	3	20	11	0	12	132

EXPERIMENT CONDUCTED IN 1914-15.

DECORTICATED COTTON CAKE *versus* PALM NUT CAKE *versus* BRAN.

In the winter of 1914-15 a further experiment was carried out to determine the relative values of palm nut cake and bran as concentrated foods for fattening cattle, and as decorticated cotton cake along with crushed oats had already proved its worth, that was taken as the standard food, and palm nut cake and bran compared with it.

Sixteen Ayrshire bullocks were available for this experiment, and a preliminary trial was first carried out with these on lines similar to the preliminary trials of previous years, and with the same objects in view.

The cattle were weighed and put on a mixed ration, consisting of decorticated cotton cake, crushed oats, palm nut cake, and bran, in addition to hay, straw, and turnips. Being horned cattle, they were tied in stalls instead of being put in loose boxes as in former experiments.

At the end of four weeks the twelve animals that appeared to be most suitable for reliable experimental work were selected and divided into three groups, with four animals in each, so arranged that the average live weight of each lot was practically the same.

A daily basal ration, consisting of a measured quantity of hay, straw, turnips, 2 lbs. decorticated cotton cake, and 2 lbs. crushed oats, was fed to each animal.

The four animals in Lot I received in addition an average over the experimental period of 1 lb. decorticated cotton cake and 2 lbs. crushed oats per animal per day; those in Lot II an average of 3 lbs. palm nut cake per animal per day; and those in Lot III an average of 4 lbs. bran per animal per day.

The experiment was continued for a period of fourteen weeks, the cattle being weighed fortnightly during that time as in previous experiments.

The live-weight gains obtained were comparatively small. They were as follows :—

Lot I.

	Live weight at beginning of experiment.			Live weight at end of experiment.			Increase.
	Cwts.	qrs.	lbs.	Cwts.	qrs.	lbs.	Lbs.
Animal No. 1, ...	6	0	20	7	2	16	164
,, ,, 2, ...	6	0	4	7	2	6	170
,, ,, 3, ...	7	1	6	8	3	16	178
,, ,, 4, ...	7	3	2	8	3	0	110

Average increase, 155·5 lbs. Weekly increase, 11·1 lbs.

Lot II.

	Live weight at beginning of experiment.			Live weight at end of experiment.			Increase.
	Cwts.	qrs.	lbs.	Cwts.	qrs.	lbs.	Lbs.
Animal No. 5, ...	6	0	16	6	3	20	88
,, ,, 6, ...	6	3	18	7	3	8	102
,, ,, 7, ...	7	0	26	8	1	16	130
,, ,, 8, ...	7	2	2	8	2	22	132

Average increase, 113 lbs. Weekly increase, 8 lbs.

Lot III.

	Live weight at beginning of experiment.			Live weight at end of experiment.			Increase.
	Cwts.	qrs.	lbs.	Cwts.	qrs.	lbs.	Lbs.
Animal No. 9, ...	7	0	0	7	3	4	88
,, ,, 10, ...	6	0	14	7	0	4	102
,, ,, 11, ...	7	0	15	8	0	18	115
,, ,, 12, ...	7	1	4	8	0	20	100

Average increase, 101¼ lbs. Weekly increase, 7·2 lbs.

Summary of Increases in Live Weight.

Lot	I,	average weekly gain per animal,	11·1 lbs.
,,	II,	,, ,,	8 ,,
,,	III,	,, ,,	7·2 ,,

It will be seen from the foregoing results that decorticated cotton cake and crushed oats again proved its superiority, and undoubtedly this is a ration that can always be relied upon to give good results.

There is not much difference in the live weight increases obtained from the ration containing palm nut cake and that containing bran, but what difference there is is in favour of palm nut cake. When we take into account the fact that only 3 lbs. of palm nut cake was fed as against 4 lbs. of bran, it is clear that as a food for fattening cattle, palm nut cake, though by no means equal to decorticated cotton cake and crushed oats, is very much better than bran.

It is perhaps well to point out that although this experiment was conducted under ideal conditions, too great stress should not be put upon the results till they have been confirmed by other experiments, as only a small number of animals were employed. Nevertheless, there is good reason for believing that the results obtained indicate fairly well the approximate relative values, as measured by beef production, of the feeding stuffs employed.

The writer desires to take this opportunity of expressing, on behalf of the Governors of the West of Scotland Agricultural College, their great indebtedness to the Directors of

the Crichton Royal Institution, for placing at the disposal of the College the very excellent facilities which that institution affords for the conduct of such experiments.

Special thanks are also due to Mr. Will, of the Crichton Farm, who took a keen interest in all the experiments, and under whose capable supervision they were carried out; Mr. Gillies, County Lecturer for Dumfriesshire, who acted on behalf of the College, and rendered specially valuable assistance, particularly in connection with the weighing of the cattle, the measuring and weighing of the foods used, and the keeping of all records in connection with the experiments; and to Professor Berry who very kindly carried out the analyses of the foods used.

CONCLUSIONS THAT MAY BE DRAWN FROM THE EXPERIMENTS.

1. Decorticated Cotton Cake and Soya Bean Cake each proved decidedly superior to the mixture of Linseed Cake and Undecorticated Cotton Cake, even when 1 lb. additional of the mixture was fed.

2. The difference between Decorticated Cotton Cake and Soya Bean Cake is not very great, but the balance is in favour of Decorticated Cotton Cake, although that feeding stuff cost £1 more per ton than the Soya Bean Cake.

3. The return per ton of home-grown produce consumed depends to a very great extent on the concentrated feeding stuff fed along with it. The return for every ton of oats, hay, straw, and turnips was very much greater when fed along with Decorticated Cotton Cake, than when fed along with a mixture of Linseed Cake and Undecorticated Cotton Cake.

4. There is good reason for believing that Palm Nut Cake is superior to Bran as a food for fattening cattle, but that both of these feeding stuffs are inferior to a mixture of Decorticated Cotton Cake and Crushed Oats.

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REPORT

ON

CALF FEEDING EXPERIMENTS

CONDUCTED AT

THE COLLEGE FARM, KILMARNOCK,

IN

1914 and 1915,

BY

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GLASGOW, 1916.

Calf Feeding Experiments conducted at The College Farm, Kilmarnock, in 1914 and 1915.

INTRODUCTORY.

In view of the present National crisis and of the urgent need for increasing food supplies in every possible way, the time seems opportune for submitting the following short report on the calf feeding experiments conducted at the College Farm, Kilmarnock, in the spring and summer of 1914 and of 1915.

There cannot be the slightest doubt as to the advisability of rearing a larger number of calves in the year on which we are just entering. It is one of the best of all methods of ultimately increasing food supplies.

Of course calves reared in the early part of 1916, except those intended for veal, would not contribute directly to our food supplies until the end of 1917 at the very earliest, but they might, and in all probability would, contribute indirectly, because the keeping of an increased head of stock would naturally make the farmer pay more attention to earlier maturity. Consequently many of the calves dropped late in 1914 or early in 1915 would, if intended for beef purposes, probably be fattened at an earlier age. In special cases a few of those intended for cows might also be brought a little earlier into profit.

If the maximum benefit is to result from rearing a larger number of calves two points should be kept in view.

1. The very best class of calves should be selected for rearing, because these will cost no more to rear, and will be of infinitely greater value when reared. In this connection the importance of using good sires cannot be too strongly emphasised.

2. The cheapest possible methods of rearing the calves, consistent with efficiency, should be adopted. In too many cases the rearer is working in the dark, having only a very hazy idea of the actual cost of rearing, and, undoubtedly, this is after all the vital factor.

OBJECTS OF THE EXPERIMENTS.

The main object of the experiments was the finding of a cheap yet efficient food on which calves could be successfully reared, but in addition to this, accurate information as to the cost of rearing, was desired.

It is well known that calves respond better to Nature's food—their mother's milk—than to any other method of feeding. Such a method of rearing, however, is a very costly one, and one that in many cases is quite impossible. The experiments under consideration were conducted for the purpose of testing other methods of feeding calves, with a view to finding a method not greatly inferior to Nature's method as regards the live weight increase made by the calves, but one that would be very much more economical, and consequently more widely applicable.

METHOD OF CONDUCTING THE EXPERIMENTS.

The first experiment was carried out in the spring and summer of 1914, and it was repeated in 1915 in order to confirm the results.

In both years 16 calves were selected for the experiment. They were all Ayrshires, and for the most part home-bred. They were divided into four groups, with four calves in each group. Each group was housed in a separate pen, but all were under the same roof, and were tied up. For the first four weeks of their lives the calves were all fed exactly alike, their ration during that period consisting solely of whole milk. The milk was given at blood heat. A comparatively small quantity was fed during the first few days, but the amount given was steadily increased, the quantity consumed during the four weeks being equivalent to an average of $1\frac{1}{2}$ gallons per calf per day for this period. After the first three days the calves were fed twice a day. Prior to that time the poorer drinkers were fed three times a day. This method of feeding entirely on whole milk for the first four weeks adds considerably to the cost of rearing, but it gives the calves a much better start in life, and that has a far-reaching effect.

The feeding pails were kept scrupulously clean, being thoroughly scalded after each time they were in use.

At the end of four weeks the calves were gradually put on to the different rations to be tested, two weeks being taken to effect the full change. This meant that the calves were getting a little whole milk until they were six weeks old. At that age the whole milk was withdrawn entirely, excepting in the case of one group of calves to be fed on whole milk right through, and taken as the control group.

EXPERIMENTAL RATIONS.

The different rations tested were four in number, and were as follows :—

1. Whole Milk.
2. Separated Milk and Crushed Oats.
3. Separated Milk and Maize Meal.
4. Whey and a Special Calf Meal.

In addition to these foods hay was added to all the rations when the calves were six weeks old, and two weeks later linseed cake was introduced.

The average live weight of the calves in the different groups at the end of the first four weeks feeding was approximately 110 lbs.

Full particulars of the rations fed, and of the live weight increase made by each calf during the experiment, are as follows :—

LOT I.—RATION—WHOLE MILK.

In both years four calves were fed on this ration, the actual quantity of whole milk consumed being equivalent to an average of $1\frac{3}{4}$ gallons per calf per day over the whole experimental period. Hay was fed *ad lib.* from the time the calves were six weeks old, the quantity consumed during the remainder of the experimental period being equivalent to an average of about 2 lbs. per calf per day.

Linseed cake was introduced when the calves were eight weeks old. A very small quantity was given to begin with, but this was steadily increased as the calves increased in weight, the amount consumed being equivalent to an average of 1 lb. per calf per day for the time that it was fed.

The individual live weight gains made by the different calves on this ration were as follows :—

SEASON 1914. DURATION OF EXPERIMENT—16 WEEKS.

Calf No. 1—	Live weight increase,		245 lbs.
Calf No. 2—	„	„	242 „
Calf No. 3—	„	„	259 „
Calf No. 4—	„	„	205 „
	Total increase, ...		951 lbs.
Average increase per calf, ...		...	237¾ „
Average weekly increase per calf, ...			14·85 „

SEASON 1915. DURATION OF EXPERIMENT—12 WEEKS.

Calf No. 1—	Live weight increase,		171 lbs.
Calf No. 2—	„	„	165 „
Calf No. 3—	„	„	149 „
Calf No. 4—	„	„	119 „
	Total increase, ...		604 lbs.
Average increase per calf, ...		...	151 lbs.
Average weekly increase per calf, ...			12·6 „

The one serious objection to this method of rearing calves is the cost thereof. The live weight gains are all that could be desired, but the cost at which they are obtained is prohibitive, at least in the case of ordinary commercial animals.

If we take the whole milk at 7d. per gallon, linseed cake at £10 per ton, and the hay at £3 per ton, the average weekly cost of the ration over the full experimental period in 1914 is 7s. 11d. per calf, and the cost per lb. live weight increase 6·4d.

In the 1915 experiment, which extended over a period of 12 weeks instead of 16 weeks, and when the live weight gain was 12·6 lbs. per week as against 14·85 lbs. in the 1914 experiment, the weekly cost of the ration was 7s. 10½d. per animal, and the cost per lb. live weight increase 7½d.

Summary of Results from Whole Milk Ration.

1914 Experiment.
- Average weekly increase per animal, 14·85 lbs.
- Average cost of ration per week, 7s. 11d.
- Cost per lb. live weight increase, 6·4d.

1915 Experiment.
- Average weekly increase per animal, 12·6 lbs.
- Average cost of ration per week, 7s. 1½d.
- Cost per lb. live weight increase, 7½d.

LOT II.—RATION—SEPARATED MILK AND CRUSHED OATS.

As already indicated, the calves on this group were fed on whole milk for the first four weeks of their lives, then gradually changed to a ration consisting of separated milk and crushed oats, two weeks being taken to complete the change. For this transition period the whole milk, separated milk and crushed oats fed were equivalent to an average of ¾ gallon whole milk, 1 gallon separated milk, and ¼ lb. crushed oats per calf per day. For the remaining 14 weeks of the experiment the calves received an average of 2 gallons of separated milk and ¾ lb. of crushed oats per calf per day.

As with Lot I. hay was introduced when the calves were six weeks old, and linseed cake when they were eight weeks old; the quantities fed being the same as for Lot I.

The individual live weight gains made by the different calves fed on the ration were as follows:—

Season 1914. Duration of Experiment—16 Weeks.

Calf No. 1—	Live weight increase,	213 lbs.
Calf No. 2—	„ „	194 „
Calf No. 3—	„ „	220 „
Calf No. 4—	„ „	187 „
	Total increase, ...	814 lbs.

Average increase per calf, ... 203½ lbs.
Average weekly increase per calf, ... 12·7 „

Season 1915. Duration of Experiment—12 Weeks.

Calf No. 1—	Live weight increase,	142	lbs.
Calf No. 2—	„	144	„
Calf No. 3—	„	140	„
Calf No. 4—	„	147	„
	Total increase, ...	583	lbs.

Average increase per calf, ... 145¾ lbs.
Average weekly increase per calf, ... 12.1 „

The live weight gains made by the calves on the ration varied little from week to week. The only time the average weekly gain fell below 10 lbs. was in the third week of the experiment proper, when the whole milk had been entirely stopped, and while the calves were not just fully accustomed to the crushed oats.

This ration did not prove nearly so costly as the whole milk one. Taking separated milk at 2d. per gallon, crushed oats at 3s. per bushel of 42 lbs., and the same prices for whole milk, linseed cake, and hay, as for Lot I., the weekly cost of the ration in 1914 is approximately 3s. 8½d., and the cost per lb. live weight increase, 3·5d. In the 1915 experiment, which lasted only for 12 weeks, the weekly cost of the ration was 3s. 8½d., and the cost per lb. live weight increase, 3·67d.

Summary of Results from Separated Milk and Crushed Oats.

1914 Experiment.	Average weekly increase, 12·7 lbs. Cost of ration per week, 3s. 8½d. Cost per lb. live weight increase, 3·5d.
1915 Experiment.	Average weekly increase, 12·1 lbs. Cost of ration per week, 3s. 8½d. Cost per lb. live weight increase, 3·67d.

LOT III.—RATION—SEPARATED MILK AND MAIZE MEAL.

Like the calves on the rations previously considered, those in Lot III. were fed on whole milk for the first four weeks of their lives. Thereafter they were gradually put on the ration to be tested, two weeks being taken to completely effect the change.

During the transition stage the calves received a ration equivalent to a daily allowance of $\frac{3}{4}$ gallon whole milk, 1 gallon separated milk, and $\frac{1}{4}$ lb. of maize meal. The meal was scalded and fed along with the milk in the form of porridge. After the first two weeks whole milk was withdrawn entirely, and for the remaining 14 weeks separated milk and maize meal were fed, the actual quantity given being equivalent to an average of two gallons of separated milk and $\frac{1}{2}$ lb. of maize meal per calf per day. Hay and linseed cake were also introduced into the ration, and fed as in the case of Lots I. and II.

The calves took readily to the separated milk and maize meal ration, much more so than to the separated milk and crushed oats ration, but this was due to the maize meal being fed along with the milk as a kind of porridge, whereas the crushed oats were fed dry, and just after the calves had been given their milk. The live weight increases made by the different calves in this lot were fairly steady throughout the whole experiment. The individual live weight gains were as follows :—

Season 1914. Duration of Experiment—16 Weeks.

Calf No. 1—	Live weight increase,	190 lbs.
Calf No. 2—	„ „	182 „
Calf No. 3—	„ „	205 „
Calf No. 4—	„ „	193 „
	Total increase, ...	770 lbs.
	Average increase per calf, ...	192½ lbs.
	Average weekly increase per calf, ...	12 „

Season 1915. Duration of Experiment—12 Weeks.

*Calf No. 1—	Live weight increase,	— lbs.
Calf No. 2—	„ „	126 „
Calf No. 3—	„ „	143 „
Calf No. 4—	„ „	166 „
	Total increase, ...	435 lbs.
	Average increase per calf, ...	145 lbs.
	Average weekly increase per calf, ...	12·1 „

* This calf turned ill at the end of the fifth week of the experiment, and had to be removed from the pen. The results were not materially affected by its removal.

Taking the whole milk, separated milk, hay, and linseed cake at the prices previously stated, and the maize meal at 9s. per cwt., the weekly cost of this ration in 1914 is 3s. 7½d., and the cost per lb. live weight increase, 3·62d.

The cost of the ration in 1915 was again 3s. 7½d., and the cost per lb. live weight increase for that season, 3·60d.

Summary of the Results from Separated Milk and Maize Meal Ration.

1914 Experiment.	Average weekly increase, 12 lbs. Cost of ration per week, 3s. 7½d. Cost per lb. live weight increase, 3·62d.
1915 Experiment.	Average weekly increase, 12·1 lbs. Cost of ration per week, 3s. 7½d. Cost per lb. live weight increase, 3·60d.

LOT IV.—RATION—WHEY AND A SPECIAL CALF MEAL.

The calves in this group, like the others under experiment, were fed on whole milk for the first four weeks of their lives. At the end of that time they were gradually put on to the experimental ration to be tested, two weeks being taken to effect the change. The ration during the transition stage was equivalent to an average per calf per day of ¾ gallon whole milk, 1 gallon whey and ½ lb. meal. In the 1914 experiment the meal consisted of equal parts by weight of linseed meal, oat meal, fine thirds, and pea meal. In the 1915 experiment pea meal had to be omitted as it could not be obtained. The meal was made into a kind of porridge and fed along with the whey.

At the end of the transition period the whole milk was withdrawn entirely, the ration after that consisting of whey and the special meal mentioned above. Hay was introduced into the ration when the calves were six weeks old, and linseed cakes two weeks later, and the quantity fed was the same as that given to the calves in Lots I., II., and III.

The quantity of whey fed during the experimental period was equivalent to an average of $1\frac{3}{4}$ gallons per day. As the whey contains comparatively little of feeding value, a considerable quantity of meal had to be fed along with it, the quantity given being equivalent to an average of 2 lbs. per calf per day.

The calves did not take to the whey at first. Moreover this ration had a tendency to scour them, and the effect was very noticeable even when the whey was being fed in small quantities, as was the case at the beginning of the transition period, consequently the calves did not do quite so well as those on the other rations.

The trial with this ration had to terminate at the end of 12 weeks as the supply of meal was exhausted, and owing to the outbreak of war fresh supplies of similar quality could not be procured.

On the whole the calves in this Lot did rather poorly, particularly in the 1914 experiment, two of the animals becoming so badly affected with scour that they had to be removed and put on a different ration. The progress made by the other two calves was quite satisfactory.

In the 1915 experiment whole milk formed the sole ration for a period of five weeks, as against four weeks in 1914. Moreover, the transition period was spread over three weeks, as it was thought that the calves might do better on the whey ration if they were a little older, before the whole milk was entirely withdrawn. The average ration during the transition period was two-thirds gallon whole milk, one gallon whey and $\frac{3}{4}$ lb. meal. The average ration for the remainder of the experiment was $1\frac{3}{4}$ gallons of whey and $1\frac{1}{2}$ lbs. of meal.

This change of treatment was justified by the results obtained, though it added a little to the cost of rearing. By the time the milk was entirely withdrawn the calves were fairly well accustomed to the hay, as they had been getting a little for a fortnight. The fact that the linseed cake was introduced just when the whole milk was withdrawn entirely also made the want of the milk less felt. With these changes the calves did rather better on the whey ration in 1915 than in 1914, though the difference in live weight increase was practically negligible.

The live weight gains made by the calves in both seasons were as follows :—

SEASON 1914. DURATION OF EXPERIMENT—12 WEEKS.

*Calf No. 1—	Live weight increase,	—	lbs.
Calf No. 2—	„	120	„
Calf No. 3—	„	108	„
*Calf No. 4—	„	—	„
Total increase, ...		228	lbs.
Average increase per calf, ...		114	lbs.
Average weekly increase per calf, ...		9·5	„

* Calves Nos. 1 and 4 were so badly affected with scour that it was deemed advisable to remove them from the pen and put them on a different ration.

SEASON 1915. DURATION OF EXPERIMENT—11 WEEKS.

Calf No. 1—	Live weight increase,	103	lbs.
*Calf No. 2—	„	46	„
Calf No. 3—	„	101	„
Calf No. 4—	„	115	„
Total increase, ...		319	lbs.
Average increase per calf, ...		106⅓	lbs.
Average weekly increase per calf, ...		9·7	„

* This calf made variable progress, apparently due more to the individuality of the animal than to the ration on which it was fed. It is not included in the averages.

Taking whole milk, linseed cake and hay at the prices previously given, the special calf meal at 12s. 6d. per cwt., and the whey at ½d. per gallon, the average weekly cost of the ration in 1914 was 3s., and the cost per lb. live weight increase, 4·0d.

The average cost of the ration in 1915 was 3s. 4½d. per week, and the cost per lb. live weight increase, 4·2d.

SUMMARY OF RESULTS FROM WHEY AND MEAL RATION.

1914 Experiment.	Average weekly increase, 9·5 lbs. Cost of ration per week, 3s. Cost per lb. live weight increase, 4·0d.
1915 Experiment.	Average weekly increase, 9·7 lbs. Cost of ration per week, 3s. 4½d. Cost per lb. live weight increase, 4·2d.

GENERAL SUMMARY OF RESULTS.

Lot.	Season.	Ration.	Average weekly Cost of Ration.	Average weekly Live weight Inc.	Cost per Lb. Increase.
I.	1914	Whole Milk	7s. 11d.	14·85 lbs.	6·4d.
	1915		7s. 10½d.	12·6 „	7·5d.
II.	1914	Separated Milk and Crushed Oats	3s. 8½d.	12·7 „	3·5d.
	1915		3s. 8½d.	12·1 „	3·6d.
III.	1914	Separated Milk and Maize Meal	3s. 7½d.	12 „	3·6d.
	1915		3s. 7½d.	12·1 „	3·6d.
IV.	1914	Whey and a Special Meal	3s. 1d.	9·5 „	4·0d.
	1915		3s. 4½d.	9·7 „	4·2d.

COST OF REARING UNTIL WEANED.

The actual cost of rearing the calves from birth until weaned at the age of twenty weeks, as was the case in the 1914 Experiment, works out as follows :—

Lot.	Ration.	Cost of Rearing.
I.	Whole Milk, ...	£7 7 8
II.	Separated Milk and Crushed Oats, ...	4 0 4
III.	Separated Milk and Maize Meal, ...	3 19 0
*IV.	Whey, ...	—

* The calves were not continued on this ration for the full period, so the figures are not comparable.

The figures given above apply to food only, and do not include cost of attendance, housing, litter, &c. They are based on the prices previously given, and are at least 15 per cent. above the normal.

The rations fed proved quite sufficient for the bringing forward of calves suitable for beef purposes at an early date, and rather more than is actually necessary in the case of heifer calves intended for dairy stock. Taking these facts into consideration we may reasonably conclude that calves can be fed

on whole milk for the first four weeks of their lives, and afterwards reared until twenty weeks old on separated milk with Crushed Oats or Maize Meal, also with Hay and Linseed Cakes at a cost in normal times of little more than £3 per animal.

NOTES ON THE RESULTS.

It will be seen from the above summary of results that the first three lots of calves made very satisfactory progress, but the real test is the cost at which satisfactory progress is obtained. A minimum average daily gain of 1½ lbs. (10½ lbs. per week) may be taken as a fair standard of satisfactory progress. The calves fed on the whole milk made fully the highest average live weight gains, not only so, but during the whole experiment this lot of calves retained the fine bloom so characteristic of calves fed on whole milk, the difference in appearance as compared with the other calves being more noticeable towards the end of the experiment.

As previously pointed out, however, this ration is much too costly a one for the rearing of commercial animals, the cost of the live weight increase on the average of the two seasons being approximately 7d. per pound, as against 3½d. per lb. in the case of Lots II. and III. In view of this, such a method of feeding could not be expected to prove profitable unless in the case of valuable pedigree animals that require to be brought on as rapidly as possible. The cost of this ration is, however, not the only objection to it that could be put forward. The young animals fed on it became rather fatter than is necessary or even desirable in the case of calves ultimately intended for stock purposes. This objection would not apply where "baby beef" is the desideratum, but it is not unimportant where dairy stock are being reared.

The calves in groups II. and III., fed respectively on separated milk and crushed oats, and separated milk and maize meal, throve exceedingly well, their progress being all that could be desired. Their general appearance was also pleasing, and with the exception of one calf in the maize meal lot (1915 experiment) they were specially healthy.

The live weight gains of the calves in these groups were practically identical, and, as there was very little difference

in the cost of the ration, the costs per lb. live weight increase are also similar.

It was thought on the whole that the calves getting the crushed oats retained their bloom perhaps just a little better than those getting maize meal, but the difference was not very marked, and both rations can be relied upon to produce very fine calves.

There was a little difficulty in both seasons in getting the calves to take the crushed oats, and a certain amount of patience and perseverance is required at the beginning, but any little extra trouble is well repaid. The system adopted, and one which proved very suitable, was to put a small quantity of crushed oats into the pail as each calf was finishing its milk. The calf naturally busied itself for some time trying to get the last few drops of milk, and in so doing also consumed some of the oats. After ten days or so the calves evinced quite a strong liking for the oats and ate them greedily, no further difficulty being experienced throughout the experiment. The crushed oats were fed dry, consequently from the time the calves took to the oats this method of feeding entailed only the minimum amount of labour. The maize meal was not fed dry, but was scalded and made into a kind of porridge, then fed along with the separated milk. This entailed rather more labour, but on the other hand this ration had the advantage that the calves took readily to it from the very start.

The fact that crushed oats and maize meal proved such suitable foods would seem to indicate that after the first four weeks starchy foods can be successfully used to take the place of the butter fat or cream removed from the milk. In conjunction with separated milk these foods form quite a well-balanced ration. The separated milk is highly nitrogenous, much more so than whole milk, and the feeding along with it of crushed oats or maize meal tends to make the ration less nitrogenous, and rather more like whole milk in composition.

The whey ration was not a great success, the greatest drawback to it being the tendency that it had to scour the calves. This was most pronounced in the case of the younger

calves. Another rather serious drawback lay in the fact that the calves did not care for this ration, and never became really fond of it. In spite of that they did fairly well on it after they were eight weeks old, though prior to that time it proved very unsatisfactory. This lot of calves fell a little short of the standard of satisfactory progress, though the live weight gains were obtained at a reasonable cost. The calves, however, were not nearly so pleasing in general appearance, being much more "baggy" than the other lots. This was doubtless due to the introduction of a certain amount of indigestible matter in the special calf meal fed, the composition of which has already been given. The investigation into the feeding of whey is being continued in 1916 with a view to finding a method of making this a more palatable and wholesome food.

CONCLUSIONS THAT MAY BE DRAWN FROM THE EXPERIMENT.

I. That the cost of rearing calves on whole milk is prohibitive in the case of ordinary commercial animals.

II. That separated milk and crushed oats or separated milk and maize meal make suitable and economical rations for calves, provided (*a*) that the calves are fed solely on whole milk till they are four weeks old, (*b*) that the change of ration is gradually effected, and at least two weeks taken to complete it, (*c*) that hay and linseed cake are introduced into the ration after six and eight weeks respectively.

III. That the live weight increases from the maize meal and the crushed oats rations are practically identical when $\frac{3}{4}$ lb. crushed oats are fed, as against $\frac{1}{2}$ lb. maize meal.

IV. That calves retain their bloom rather better on crushed oats than on maize meal, but that both rations produce very fine calves.

V. That the whey ration fed cannot be recommended as a suitable one until calves are at least eight weeks old—(*a*) because of its tendency to scour the calves, (*b*) because of the somewhat ragged and baggy appearance which attends its use, and (*c*) because calves fed on this ration are apt to get down in condition.

SOME ADDITIONAL POINTS.

This opportunity is taken of calling attention to a few additional points which contribute in no small degree to successful calf-rearing.

Feeding of Colostrum.—It is specially important that a certain amount of colostrum or green milk be fed to begin with. The colostrum is even more digestible than whole milk. It has a slightly medicinal effect, and is required to put the stomach and intestines of the young calf into working order. The colostrum is Nature's provision for the new-born animals, and while specially valuable for these it is quite unsuitable for feeding to older calves, and when fed to them is often the cause of trouble. If for any reason colostrum is not available a substitute, such as an egg switched up with a little castor oil, should be given to the new-born calf.

Frequency and Regularity of Feeding.—All young calves, and particularly those that prove poor drinkers, should be fed three times a day for the first few days. This entails a little extra labour, but is amply repaid by results, as digestive troubles which frequently culminate in scour are often avoided by its adoption. Regularity of feeding is also very important, and is a factor which has a very direct bearing on the general health of the calves.

Quantity of Milk Fed.—The quantity of milk fed should be gradually increased as the calf grows, at least up to the time when other foods can be safely introduced. If a calf just gets the same amount of milk when four weeks old as it got when one week old it is clear that it must either be overfed when a week old, or very much underfed when four weeks old. In order that the young animals may make steady progress the rations should be steadily increased as they develop. The actual quantity of milk fed should depend on the milk available and the purpose for which the calf is intended. The milk should be either carefully measured or weighed as guessing at the quantity is very unsatisfactory.

Change of Ration.—When any change in the ration is made it should be gradually effected so that it may be as

little felt as possible. Calves are very easily upset, and an abrupt change in diet is a common cause of trouble.

Cleanliness of the Feeding Utensils — Scrupulous cleanliness, particularly of the feeding pails, is an important factor, and greatly lessens the risk of scour breaking out. The pails should always be steamed or thoroughly scalded with boiling water.

Method of Housing.—Young calves require to be comfortably housed, especially during the colder season of the year. A cement floor has a great many advantages, especially from a sanitary point of view, but it is naturally a cold floor, and if calves are housed in a building with a cement floor plenty of litter should be supplied. Peat moss litter is particularly valuable for this purpose. If calves are tied up for the first few weeks they are less liable to suck each other when they are let loose, than if allowed to run together loose from birth.

Salt, Chalk and Water.—Calves also benefit considerably, especially when fed on certain artificial rations, from having access to rock salt, chalk, and water. The salt is required for the blood, the chalk tends to check acidity and also plays an important part in bone formation, while water in some form or other is absolutely essential if the calves are to make satisfactory progress. It is not required when they are getting plenty of milk, but should always be given when the milk is withdrawn.

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West of Scotland Agricultural College.

UTILISATION OF HONEY AND WAX.

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GLASGOW, 1916.

THE UTILISATION OF HONEY AND WAX.

Honey is essentially an article of food. Prior to the introduction of the sugar-cane, it was the natural sweet of mankind.

Bees do not, as commonly supposed, collect honey. They gather nectar from the nectaries, or honey glands, of the flowers. This nectar consists chiefly of cane sugar and water. The cane sugar, by a process of inversion—brought about by certain glandular secretions of the body of the bee—is converted into the simpler sugars, dextrose and levulose. Part of the water of the original nectar is evaporated by the comparatively high temperature of the hive. Honey, then, is a predigested food, and, unlike ordinary sugars, is easily assimilated. Cane sugar, on the other hand, needs inversion, through the action of the gastric juice, before the human system can utilise it. Consequently honey is an excellent food for people with weak and impaired digestions, as it assists in building up the body without seriously taxing the digestive system.

Honey, being immediately and completely assimilated, is also valuable from a medicinal point of view. Functionally it is productive of heat, and leaves practically no residue in the system. It finds its way into many of the present-day advertised cough cures.

Children, especially suckling infants, have a natural craving for sweets, which can be more satisfactorily appeased by the application of honey than by sugar. The honey is much more easily digested, and is a purer form of sweet.

Honey can take the place of sugar in cooking, and it will be found to impart a more agreeable and appetising flavour to the produce.

Another great advantage of honey in cooking is that cakes in which honey is used instead of sugar will keep longer. In all households a competent cook can, with discretion, use honey in many varieties of foods. It is practically safe to estimate

that, weight for weight, honey will impart the same degree of sweetness as sugar. It should, however, be borne in mind that, as honey contains water, it is necessary to limit the quantity of other liquids, such as milk, &c.

Wax.

Bees produce wax in their bodies by means of a chemical process. They consume honey, and by remaining in a comatose state, in which they generate heat, the wax exudes in small white scales into the eight wax pockets which are situated under the abdomen. It is estimated that it takes 20 lbs. of honey to produce 1 lb. of wax.

Beeswax is largely used by dentists and druggists, polishers, blacking manufacturers, and candlemakers.

Below are given recipes relative to the utilisation of honey and wax. Several of the recipes are advocated by leading authorities in apiculture :—

CAKES.

Rich Plum Cake.

½ lb. butter, ½ lb. honey; beat these with the hand well together; add four eggs, one at a time, and well beat each one with the butter and honey; lightly mix in 1¼ lbs. flour, previously mixed with large teaspoonful of baking powder; then lightly mix with the whole ½ lb. of sultana or valencia raisins. Bake at once thoroughly.

Honey Cakes.

Little honey cakes are very popular for afternoon tea. One cupful of flour, sifted with two teaspoonfuls of baking powder and a quarter of a teaspoonful of salt; beat one egg till very light; add one teaspoonful of butter and one-third of a cupful of honey; add to flour, with a few drops of cinnamon extract or a pinch of ground cinnamon. Drop in spoonfuls on a buttered tin, and bake in a quick oven.

Honey Oatmeal Cookies.

One cup honey, one of sour cream, two eggs, two cups oatmeal, two cups of flour, one tablespoonful of grated chocolate or cocoa, one teaspoonful baking soda, one teaspoonful mixed spice, and a half teaspoonful salt; one cup chopped raisins. Sift the dry ingredients together, except oatmeal; add all other ingredients; stir well, and drop by teaspoonfuls on to greased tins, and bake.

Honey Bread.

Three cupfuls flour, two cupfuls of milk, one-third cupful of honey (or more according to taste), portion of yeast, dissolved in a little warm water, quarter teaspoonful salt. Mix thoroughly, and set in warm place to rise; when very light, add beaten egg, three tablespoonfuls melted butter, and flour for soft dough; knead lightly. Fruit and carraway seeds may be added at discretion. Cover, and let it rise again until double the bulk. Bake in moderate oven, glazing with sugar and water just before removal from oven.

Honey Muffins.

Sift two cupfuls of flour with two teaspoonfuls baking powder and a quarter-teaspoonful salt; rub in two level teaspoonfuls butter, two eggs well beaten, five tablespoonfuls of milk, and one-third cupful of honey; mix, and pour into well-greased muffin-tins, filling half full. Bake in moderate oven. These may be covered with stewed fruit or whipped cream, and served for cottage puddings.

Honey Gingerbread.

Four cupfuls flour, two teaspoonfuls ground ginger, half cupful of butter, three-quarters cupful honey, two eggs, quarter teaspoonful salt, half cupful sultanas, quarter cupful chopped peel, two teaspoonfuls baking powder; mix flour, salt, baking powder, and ginger; add raisins and peel; melt the butter, honey, and a little milk together in a saucepan, then cool and add to the flour, with the eggs well beaten. Turn into buttered and floured tin, and bake.

Ginger Honey Cake.

One cup honey, half cup of butter or dripping, half cupful sour milk; warm these ingredients together, and add one tablespoonful ginger and one teaspoonful of soda, sifted in with flour enough to make soft batter. Bake in flat tin.

Honey Drops.

One-third cup of honey, one teaspoonful butter, one egg (well beaten), two-thirds cup flour, sifted with half teaspoonful baking powder and pinch of salt. Drop by teaspoonfuls on a tin, and bake in quick oven. These proportions will make about twenty cakes.

Parkin.

1 lb. flour, 1 lb. oatmeal, 1 lb. honey, 6 ozs. butter, 2 ozs. lard, $\frac{1}{4}$ lb. sugar, one and a-half teaspoonfuls ground ginger, teaspoonful of baking powder, half teaspoonful milk; mix flour, oatmeal, ginger, and baking powder; then rub in butter and lard; add the sugar; and mix to a stiff paste with the honey and milk. Bake in a slow oven.

Honey Ginger Snaps.

One pint honey, $\frac{3}{4}$ lb. butter, two teaspoonfuls ginger. Boil together a few minutes, and when nearly cold put in flour until it is stiff. Roll out thin, and bake quickly.

Honey Fruit Cake.

Two eggs, two and a-half teacupfuls of flour, one teacupful honey, half teacupful butter, half teacupful sweet milk, one and a-half teaspoonfuls baking powder, $\frac{1}{2}$ lb. raisins, $\frac{1}{2}$ lb. currants, one and a-half teaspoonfuls mixed spice. Bake in slow oven. This cake will keep moist for months.

Honey Cake.

3 lbs. of honey, 3 lbs. flour, 1 oz. powdered ammonia, small teacupful ground cinnamon, half teaspoonful ground cloves, 6 ozs. orange peel or citron (cut very fine), 4 ozs. sweet almonds

(cut very small). The ammonia evaporates in baking. Boil the honey, and remove the scum; then pour the honey into the vessel in which the paste is to be made; leave it to cool; add flour and other ingredients, except ammonia (latter must not be added until flour and honey have been mixed and become cold); mix the ammonia in a cup with a few drops of cold water to form a thick paste, then mix it up with the rest; take a piece of the paste, roll it out into a cake not over a quarter of an inch thick, and cut up into convenient sizes; put these in a flat tin, and bake in a hot oven 12 to 15 minutes. This is a very old and excellent recipe, used by the monks of Buckfast Abbey.

PUDDINGS.

Apple Charlotte.

2 lbs. apples sliced, three cupfuls stale bread crumbs, half cup honey, quarter cup butter, grated rind and juice of a lemon, quarter teaspoonful of spice or grated nutmeg. Melt the butter, and stir lightly into the bread crumbs; cover the bottom of a buttered pie-dish with crumbs, and spread over one-half the apples; pour over half the honey, spice, and lemon juice and rind mixed together; repeat; cover with the remaining crumbs, and bake 40 minutes in moderate oven. Cover at first to obviate crumbs browning too quickly. Serve with sugar and cream.

Honey Cornflour Pudding.

Four cupfuls milk, quarter teaspoonful salt, one-third cup of honey, six and a-half tablespoonfuls of cornflour. Mix the honey, salt, and cornflour; stir in the milk (hot) gradually until smooth; stir until the mixture thickens; and cook for about 10 minutes. Turn into wet mould, and serve cold, with cream, and sugar or fruit.

Steamed Suet Pudding.

Three cupfuls flour, one and a-half teaspoonfuls pudding spice, half teaspoonful salt, one and a-half teaspoonfuls of ground ginger (more, if liked), two cupfuls of finely chopped suet, one cupful of honey, one cupful of milk, one cupful of

chopped raisins if preferred. Mix the dry ingredients, and add the suet and raisins; add the honey to the milk, and stir into the dry mixture. Turn into a buttered mould, and steam 3 hours. Serve hot, with sauce or cream.

Simple Fig Pudding.

½ lb. figs, ½ lb. suet, ½ lb. bread crumbs, and honey. Chop the suet and figs finely; then mix with the bread crumbs; add sufficient honey to make a paste; butter a mould; pour in mixture; and boil 2½ hours.

Fruit Confection.

1 lb. dried figs, ½ lb. each of dried peaches, prunes, and raisins, one cup honey, one cup chopped nuts. Run the fruit through a meat chopper; mix in the honey and nuts; and knead; press into a form; cut in squares; roll in powdered sugar; and serve.

Mince Meat.

½ lb. apples (chopped), ½ lb. currants, ½ lb. raisins, ¼ lb. peel (chopped), ½ lb. honey, quarter teaspoonful cinnamon, grated rind and juice of lemons to taste, little salt, mix thoroughly.

Fruit Salad.

Slice six bananas and two oranges, and mince a large apple; add three tablespoonfuls honey; dissolve pint tablet of pine-apple jelly, let it slightly cool, and pour over the ingredients. Allow time to set.

SWEETS.

Honey Caramels.

One cup honey, cup granulated sugar, three tablespoonfuls sweet cream or milk. Boil until it hardens when dropped into cold water (not too brittle); pour into greased dish, stirring in vanilla essence just before removing from fire. Let it be half inch deep in dish. As it cools cut in squares. For chocolate caramels add to the above one tablespoonful of melted chocolate just before taking off stove, stirring it in well.

Honey Rock.

Boil honey, any quantity, until it hardens when dropped into cold water; stir until it becomes white. A pound requires ten minutes boiling and stirring. Care must be exercised not to burn honey.

Honey Chocolate.

Cut *granulated* comb honey into inch squares, dip each into melted chocolate. Allow to cool and dip again.

Toffee.

A pint of honey, two tablespoonfuls butter, a tablespoonful vinegar, a quarter teaspoonful baking soda, a teaspoonful lemon essence. Put honey, butter, and vinegar into saucepan, and boil until mixture hardens when dropped in cold water; then stir in soda and essence. Pour into buttered tin to cool. When half cold, mark into squares. The saucepan should be removed from the fire before stirring in the soda and essence, or it will boil over. The saucepan should not be too full.

Nut Creams.

Two-thirds cup of honey, three cups granulated sugar, whites of two eggs, half cup boiling water, teaspoonful of vanilla, one cup of ground nuts. Boil honey, sugar, and water until, if tested in cold water, it is brittle; pour this in a thin stream over the whites of two well-beaten eggs, beating the whole all the time until like a thick cream, then stir in briskly the nuts and vanilla, and pour into buttered dish. When hardened cut in squares.

French Honey Candy.

Melt in an enamelled saucepan one part of gelatine in one part of water, stirring well; when arrived at the state of a soft paste, add four parts of warmed honey, stirring briskly; take from the fire; add desired flavour (such as essence of almond, vanilla, lemon, &c.), and colour if desired, mixing carefully, and pour into a shallow, lightly greased dish. Let it dry for a few days.

Honey Chocolate.

Melt ½ lb. of gelatine in half pint of water; add 5 lbs. of honey, thoroughly warming the same; and add to this 2 lbs. cocoa, flavour with vanilla when taken off the fire, and pour into greased dishes or moulds.

BEVERAGES.

Honey Syrup.

Any juicy fruits, such as raspberries, plums, strawberries, &c., can be pressed and the liquid mixed with honey in the ratio of 2 lbs. of honey to 1½ lbs. of fruit juice. Boil together until the mixture thickens, taking off the scum as it rises. An excellent beverage can be obtained by mixing a little of the juice with mineral or plain waters.

Honey Vinegar.

To 1 lb. of honey add five and a-half pints of water; stand same in a wooden or pitcher vessel, taking care to cover it with cheese-cloth, to exclude insects; stand in the sun. In from 4 to 6 weeks it will become strong vinegar, with an excellent flavour.

Mead.

Boil 7 lbs. of honey in two gallons of water for an hour, straining it very carefully, allowing same to cool; when nearly cool, stir in two tablespoonfuls yeast, and put the whole in a cask in a cool place. Bottle after 12 months, and use 3 months later.

Mead.

3 lbs. of honey and the peel of four lemons in two gallons of water; boil for half an hour, and skim well; ferment with yeast; let it stand in a cask for 6 months, then bottle for use. If desired to keep for several years, use 4 lbs. honey to one gallon water.

Metheglin.

Metheglin is more like a liqueur. Mix honey and water strong enough to float an egg; let it stand 3 or 4 weeks to ferment, and flavour to taste.

TOILET.

To soften and whiten the Hands.

1 oz. honey, 1 oz. lemon juice, 1 oz. eau-de-cologne; shake well.

MEDICINE.

Cough Mixture.

½ lb. honey, half pint vinegar; add pennyworth of aniseed, pennyworth syrup of squills, pennyworth laudanum, pennyworth paregoric; put into quart bottle and fill up with boiled water. Dose, one tablespoonful occasionally. A chemist will, on application, place the above four ingredients in a bottle, when the honey, vinegar, and water can afterwards be added.

Laxative Drink.

Dissolve a level teaspoonful of cream of tartar in a little boiling water, adding tablespoonful of honey, filling up glass with water as preferred. This is especially good in case of a feverish cold.

Cough Mixture.

Take a large, strong onion; let it simmer in a quart of honey for several hours, after which strain, and take a teaspoonful occasionally. This eases a cough wonderfully.

MISCELLANEOUS.

Sewing Wax.

A small piece of beeswax will be found useful for drawing along the thread previous to sewing. This will add to the life of the thread considerably.

To make Boots Waterproof.

2 ozs. beeswax, 1 oz. Burgundy pitch, one pint boiled oil, 1 lb. mutton suet, a little lamp black. To be boiled together on a slow fire until well amalgamated; rub it into the boots before the fire. The paste should be applied with a small brush, and worked into the seams thoroughly. The soles can also be rubbed. Boots so treated will resist damp even in deep snow.

Waterproofing Boots and Shoes.

Melt together one pint linseed oil, 8 ozs. suet, 6 ozs. beeswax, and 1 oz. resin. Apply with a brush.

Furniture Polish.

Melt beeswax, turpentine, and linseed oil in equal parts, and thoroughly mix. Apply with soft cloth, and polish.

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West of Scotland Agricultural College.

Practical Advice to Beginners in Bee-keeping.

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GLASGOW, 1916.

ADVICE TO BEGINNERS IN BEE-KEEPING.

Bee-keeping is one of the most profitable of the minor rural industries. It is specially suitable for cotters, crofters, and small-holders, and while it cannot rank as one of the main sources of income on the average farm, yet it can be made one of the most remunerative side lines. To the horticulturist and market gardener it should make a special appeal. Further, it is an occupation which, from its nature, is particularly well-adapted for ladies. The initial capital required is small, the returns are quick, while the time and labour spent in operating a few colonies is amply repaid by the pleasure and profit to be derived from this fascinating pursuit.

From the national point of view, the industry deserves every encouragement. Honey, to the value of £46,921, was imported into Great Britain during the months of June, July, and August, 1915. This foreign honey is decidedly inferior to Scottish honey. The production of honey in Scotland is not equal to the demand, yet many hundred tons of nectar are annually lost, owing to insufficient colonies of bees. The money spent abroad could easily be retained at home.

Natural History.

A colony of bees in the summer consists of the following associated members :—the queen, the workers, and the drones.

Queen.

The queen, or mother, is the only perfectly developed female in the hive. She is a little longer in the body, and her movements are slow. She has a curved sting, which is used as an ovipositor. Her chief function is to deposit eggs, from which

emerge the other occupants of the hive—workers and drones. A good queen in the summer will lay from two to three thousand eggs per day. She will live from 3 to 5 years, but it is found that a queen in her second year has attained her maximum power of egg-production. To secure the best results from a colony of bees, it is therefore essential that a young queen should always be at the head of the colony. For example, a queen reared in July, 1915, is at her best during 1916. The queen deposits eggs of two kinds, those which give rise to workers and those which give rise to drones. Worker eggs are laid in worker cells, and under ordinary treatment produce worker bees, but under special treatment can be made to produce queens; drone eggs are deposited in drone cells.

Worker.

The worker bee is an undeveloped female. Workers are smaller in size than the queens or drones. They have a sting which deters many prospective bee-keepers from taking the subject in hand, but nature has given this weapon to the insect, not as a means of offence, but for the purpose of protecting itself from its natural foes. The workers have many enemies, and were it not for the sting, the race would soon become extinct. In a prosperous colony in the summer, the workers number from 40 to 60 thousand. They build the cells, collect the nectar and pollen, feed the young larvæ, and perform practically all the work in the beehive. Their span of life is short—from 6 to 8 weeks in the summer. During that period they work incessantly, and wear themselves out in their arduous labours. Those workers that are reared in the late autumn live through the winter, and perform a little work in the early spring. It takes about 3 weeks from the time the egg is laid to produce a worker bee. When the worker bee emerges from the cell it is very weak, and for the first week or so acts in the capacity of a nurse bee in the hive, *i.e.*, to feed the grubs or larvæ. After this period it is strong enough to take its place with the other workers in the fields. It naturally follows that, to obtain the maximum production of honey in a single colony, it is important to have the hive teeming with worker bees at a

time when nectar can be collected in the fields. This must be the chief aim of the bee-keeper. The greater the number of worker bees the hive contains at the right time, the greater will be the profit.

Drone.

The drone is the male bee. There are usually two or three hundred drones produced in all normal colonies. The number depends to a great extent upon the number of drone cells in the hive. Their function is to fertilise the young queens. At the close of the honey season, when their services are no longer required, they are turned out of the hive by the workers, and left to die. The drone does not possess a sting, and has no means of defending himself. Consequently he falls an easy prey to the workers. Neither has he any means of procuring his food in the fields, in consequence of his extremely rudimentary tongue. He is therefore dependent upon the worker for his sustenance. The drone is produced from an egg laid by the queen in a drone cell. The time occupied to produce a drone from the laying of the egg is 25 days. Drones from poor colonies are undesirable, and should not be encouraged. To improve the breed of bees, the bee-keeper should make a point of raising a few hundred drones only from those colonies which give the best returns.

Position and arrangement of apiary.

Beehives take up little room, and anyone with a small garden can keep a few colonies of bees. This does not imply, however, that any position will do for the hives, and on the selection of a suitable site will depend in a large measure the success of the bee-keeper. The site should be carefully selected. It should be dry and free from weeds. It should be sheltered from the north and east winds, and should face the south—which is the most favourable aspect. Shelter from the north and east winds will prevent much loss of life which usually occurs when the hives are placed in an exposed position. Spreading ashes on the surface will naturally assist in rendering the site dry, and in suppressing the growth of weeds, which harbour insect pests

inimical to the colony. The hive should be raised from the ground by means of legs, and if these are made to rest on bricks and tiles they will not decay so readily. Hives should not be too closely crowded. They should stand 6 feet apart, but if the available space is limited they may be set a little closer. A pathway at the rear of the hives is extremely useful, for then manipulations can be carried out without interference with those bees which are returning from the fields.

Hives.

The essential parts of a modern beehive are :—stand on legs, moveable floor board outer case, inner brood chamber, lifts, and roof, and surplus accommodation.

Hives of many designs are now in the market, but it is most important that the hives should be accurately constructed. If not, the bees will either use an excessive amount of propolis, or build combs in the ill-fitting spaces. Perhaps the most popular hive is the "W.B.C." hive—so called after the inventor, William Broughton Carr. It consists essentially of a stand, with legs, a floor board, a moveable brood chamber, containing 10 frames and a dummy frame, and outer brood case, roof, lifts, and chambers for the storing of honey. The advantages of this hive are :—it is easily kept clean; its capacity can be increased by the addition of more lifts; it is well adapted to the production either of "extracted" or "comb" honey; and with it operations such as "doubling" and "uniting" can be carried out with the greatest of ease. A hive of this type, however, is not suitable for bee-keepers who send their bees to the heather moors in Autumn, because it is more difficult to pack than a hive of simpler form, and entails greater expense in transit.

Hives with fixed brood chambers can be purchased more cheaply. But whatever type the bee-keeper adopts, he should endeavour to have all the hives made of similar size and shape, so that the relative parts are interchangeable. Such uniformity in the apiary will considerably simplify his work.

Hives should always be purchased new from manufacturers of bee appliances. It is poor economy to buy second-hand

hives at sales, because there is always the risk, and indeed the probability, that their late tenants have died from disease.

On receipt of the new hive, the bee-keeper should examine its component parts. The roof and lifts being removed, the following parts will be exposed :—section rack, shallow super, queen excluder, and quilts. Below these will be the brood chamber—a compartment containing 10 frames and a dummy frame; the former will be filled with sheets of "worker" foundation, and wired. The shallow super, section rack, and queen excluder are removed and placed under cover, for future use. The quilt is arranged over the brood chamber, and the lift and roof added. If the hive is not already painted on receipt from the dealer, it should be given two coats of paint. When dry, it will be ready for a swarm of bees.

Appliances.

When more than one colony is kept, the bee-keeper should also provide himself with a honey extractor, for extracting honey from combs; straw skep, to hive swarms, and super clearer to rid the honey chambers of the bees when removing the honey.

Purchasing Bees.

The beginner may start business by purchasing a swarm of bees from a local bee-keeper, or by buying an established stock. The first is perhaps the best and easiest method for the average beginner, for then the local dealer will assist the novice in placing the bees in the hive—though this is not a difficult operation. Swarms of bees are usually sold by weight, at 2s. 6d. to 3s. per lb. It is advisable not to purchase a swarm under 5 lbs. Whether or not honey will be obtained in the first season will depend on the time when the swarm is purchased, and the season. If the swarm be obtained in May or early in June it is possible, if the atmospheric conditions are favourable, to obtain a supply of honey the first season.

On the other hand, the apiarian may prefer to buy an established stock on 8-10 frames, from a reliable dealer in bees. If the stock is obtained early in the season, the bee-keeper may

rely upon securing a yield of honey the first season. A word of warning may be given here. In consequence of the prevalence of bee disease in the country, the bee-keeper should only trade with reliable dealers, and obtain, at the time of purchase, a guarantee of the healthy state of the bees.

Placing the Swarm into the Hive.

The swarm may be received either in a skep or in a box. If in the former, the mouth of the skep will be covered with a piece of cheese-cloth or coarse sacking, tied with string. The box, on the other hand, will be covered with a lid, consisting of perforated zinc attached to a wooden frame, which is held in position on the top of the box by means of screws.

In transferring the swarm to the hive, the beginner should proceed methodically. The entrance should be opened to its full width. A temporary stage in the form of an inclined plane leading up to the hive entrance is erected. This consists of a long board, one end resting on the alighting board of the hive, and the other end on the ground. Over this board a white cloth should be evenly laid. Previous to transferring the bees from box or skep, the bees should be given a little smoke. Having removed the cover, the operator should now lift the box or skep, turn it upside down, and with a sharp jerk dislodge the swarm on to the improvised landing stage. The natural inclination of bees is to run upwards, and in a little time they will all be safely in the hive. A sharp watch ought to be kept to see that the queen is safely in the hive. If the weather be cold at the time, the bees will not run quickly, but a little smoke will have the desired effect.

When an established stock has been purchased, the bee-keeper will find it a simple task to remove the combs with bees from the travelling box into the frame hive.

Handling and Manipulating Bees.

To manipulate bees, the operator must necessarily have a black net veil, to protect the face from stings, and a smoker,

to subdue and control the bees. The veil should be broad enough to stretch round the rim of a straw hat, and long enough to allow the free end being well tucked under the collar of the coat. A piece of elastic sewn round the top of the veil will hold it tightly in position around the crown of the hat. As regards the smoker, the best smouldering materials are corrugated-paper, old bags, corduroy, and decayed wood; any of these, when ignited, will, by the action of the bellows, give off a good column of smoke. The smoker, once ignited, may be kept alight when not in use by standing it vertically with its nozzle upwards.

All manipulations should be performed gently and slowly. Clumsiness only serves to irritate the bees. To inspect the colony, a few puffs of smoke should be blown in at the entrance, and, after allowing 2 to 3 minutes for this to take effect, the bee-keeper should take up his position at the back of the hive, and gently remove the roof. The lift is next taken off, without any jarring effect. Following this, the wrappings over the brood chamber, with the exception of the quilt next the bees, are removed *en bloc*. In removing the quilt, the corner should be slightly raised, and a few whiffs of smoke blown into the hive. This process should be continued until the quilt has been entirely removed. The smoke frightens the bees, and they instantly rush to their cells and partake of their own honey, after which they are exceedingly docile. An examination of the brood chamber should not occupy more than a few minutes. The bee-keeper should first of all remove the "dummy" from the back or the side of the hive. This is a piece of wood, shaped like a frame, and when removed enables the bee-keeper to have more space at his disposal to lift out the frames. Each frame should be taken out evenly and gently, care being taken not to crush any of the bees during this operation. When putting back the frames, the same precaution should be observed. If the bees get at all irritable or out of hand, they can be controlled by the application of a little more smoke.

No colony should be inspected when the thermometer is below 60 degrees Fahrenheit, or the brood will be chilled. Bees can be more easily handled on warm, sunny days than in cool or windy weather.

If the bee-keeper should happen to get stung at any time, he should push the sting from the flesh by the finger nail. Any attempt to pull out the sting by the thumb and finger simply results in sending more poison into the flesh. The poison—formic acid—is rarely dangerous, and in the course of time the bee-keeper becomes more or less immune to the same.

It is proposed, in a further bulletin, to give advice on other aspects of the subject.

LETIN 71.

West of Scotland Agricultural College.

REPORT

ON EXPERIMENTS WITH

VARIETIES OF OATS

CONDUCTED ON

FARMS IN THE COLLEGE AREA.

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REPORT ON VARIETIES OF OATS.

This Report deals with Experiments conducted in the years 1907-1911, and does not bring the Investigation into Different Varieties of Oats quite up-to-date. It was purposely delayed with a view to the inclusion of results obtained in the more recent experiments, but as the Scheme of these latter Experiments is not just on a parallel with the former, it was considered advisable to issue this as a separate Report.

This bulletin summarises the results of experiments on varieties of oats. These experiments, which extend over a period of five years (1907-1911) were conducted under the regime of ex-Principal R. Patrick Wright, whose ostensible object was to demonstrate the merits of the so-called "new" varieties of oats. Some of these varieties are now in common cultivation, and can no longer be regarded as new; others have become mere names.

The field trials were carried out on farms situated in the counties within the College area, and on soils which, in the case of individual experiments, were, so far as could be ascertained, uniform in character. The results, however, indicate that the attempt to secure uniformity in soil conditions, even within the confined limits of less than one acre, was in many cases quite unsuccessful.

The experimental plots were each one-twentieth acre in size. The number of varieties under test varied from year to year; those which proved least successful were eliminated, and others substituted in their place. The following is a list of the varieties which were experimented with during the years under review:—

1907.—Potato; Sandy; Banner; Wide Awake; Mounted Police; Besler's Prolific; Waverley; Storm King; New Abundance; Viking; Twentieth Century; Golden Rain; Siberian; Danish Island; Bavarian; Thousand Dollar; Lincoln; Awnless Probstei; White Giant.

1908.—Potato; Sandy; Banner; Wide Awake; Mounted Police; Besler's Prolific; Waverley; Storm King; New Abundance; Viking; Twentieth Century; Golden Rain; Siberian; Danish Island; Bavarian; Thousand Dollar; Lincoln; Awnless Probstei; White Giant.

1909.—Potato; Sandy; Banner; Wide Awake; Mounted Police; Besler's Prolific; Waverley; Storm King; New Abundance; Viking; Twentieth Century; Golden Rain; Thousand Dollar; Lincoln; Awnless Probstei.

1910.—Potato; Sandy; Banner; Wide Awake; Mounted Police; Besler's Prolific; Waverley; New Abundance; Viking; Golden Rain; Lincoln.

1911.—Potato; Sandy; Banner; Wide Awake; Mounted Police; Besler's Prolific; Waverley; Storm King; New Abundance; Viking; Golden Rain; Thousand Dollar; Lincoln.

It will be seen that the old-established varieties, Potato and Sandy, have been taken as the basis of comparison.

Before proceeding to tabulate the results of these trials, it may be well to call attention to some factors which *a priori* will affect the results. Variations in soil, season, and climate will effect marked variations in the yields, independent of the variety of oat. Undoubtedly, soil is the most important variant, and though in these field trials a complete dressing of artificials was given, to minimise, as far as possible, differences in chemical constitution, yet that would have little effect in diminishing the variation in physical conditions, which is of greater moment. It may be remarked here that the soils in the area of these experiments belong to several geological formations, and are of a very variable character.

The situation and exposure of the soil will also have a distinct effect on the yields of individual varieties. The newer varieties are commonly held to do best in low-lying, fertile lands, and in sheltered situations; this is true relatively, but not absolutely, for in some of these experiments, at elevations over 900 feet the "grain-bearers" still gave the best returns.

It is difficult, with such a variable climate as prevails in the south-west of Scotland, to estimate the effect of season as apart from soil. These two factors, which in an old cultivated country like ours are the most powerful in determining the yield, cannot be dissociated or considered independently, because the character of the season will always affect the physical condition, and consequently the cropping capacity, of the soil. Further, some soils suffer worse than others during an adverse season. A good average loam, well drained, will give a much less variable yield from year to year than, for example, a wet-bottomed field, which will give a very much better return in a dry year than in a wet season. The less the physical conditions of a soil are affected by seasonal variations, the more uniform will be the annual returns from that soil. An examination of the returns from experimenters in these trials has clearly demonstrated the fact that the variations in the yield of any individual variety are more pronounced in a bad season (although the general average for that season is not much below the normal), and that the greatest deviation from the mean occurs on soils whose physical condition is poor. As illustrative of the effects of season in the case of Wide Awake in this respect, it may be here stated that the standard deviation from the mean (or average yield) was approximately 21·0 per cent. in a bad season—1907—whereas it was only 12·77 per cent. in a good season—1908.

The original aim in conducting these experiments was to ascertain, by a method of direct comparison, the best cropping variety of oat, and to state the relative order of merit of the others under trial. This might have been realised if, in each of the separate experiments, the soil conditions had been individually uniform—but not necessarily the same for all—and had reliable returns been secured from all the individual plots. Neither of these conditions was realised. Take the case of soil. In the year 1910, eleven varieties were under test, and returns, fairly complete, were made from 16 farms in the College area. If the soil throughout each series of 11 plots were uniform, we might reasonably expect to observe in the returns the same sequence in cropping capacity. If Potato had a clear lead on one farm, we might expect it to be first on the other

farms. But what do we find? Lincoln had a clear lead on 4 farms; Besler's Prolific on 4; Potato on 2; Sandy on 2; while Waverley, Mounted Police, Banner, and Wide Awake each claimed precedence on one farm. This clearly establishes the fact that soil conditions were not uniform, even over small areas of eleven-twentieths of an acre (each plot being one-twentieth acre), and were sufficiently great as to negative the differences in absolute cropping capacity of the different oat varieties.

Again, through varying causes, the returns of the experimenters for all the varieties under test was often incomplete. Some oats did not get a fair trial. For example, it was frequently reported that the yield of New Abundance was very much lower than it should have been, owing to the fact that, being an early ripening oat, it suffered severely from birds. Had it got a fair chance it might have been first. Sometimes, again, the yields of one or two plots in the same experiment were reduced by the ravages of ground game, especially of these plots lodged before harvest. At other times, grub or wireworm partly destroyed the braird on some plots. So that, in many cases, the returns for all the plots could not be given correctly.

Considerations such as these rule out the method of direct comparison. There remains, however, another method of determining approximately the cropping capacity of the varieties. Regard each variety as forming the basis of a single experiment, and ascertain the average yield from all the plots on which this oat was grown—disregarding, of course, returns from plots which were partly destroyed by game, insect pests, &c.—for all the seasons under review. We can then obtain the average or mean yield for a succession of years and for a large number of different soils. If, now, in addition, we take into account the standard deviation—or experimental error—we can determine the limits within which the yield of any variety under trial will, in most cases, fall, independent of soil or season. For example, in the case of the Potato oat, the mean (average) yield of 109 tests, spread throughout the five years 1907-11, was 53 bushels per acre; the standard deviation due to soil and season was 16·88—*i.e.*, the yield, in the great majority of cases, lay between 44 and 62 bushels.

Variety of Oat.	Average Production of Grain (per acre).	Deviation from Mean.	Average Production of Straw (per acre). Tons.	Cwts.	No. of Tests.
Besler's Prolific, ...	2,631 lbs.	16·93%	1	19	84
Wide Awake, ...	2,570 „	19·32%	1	18	93
Awnless Probstei, ...	2,550 „	15·09%	2	1½	37
Mounted Police, ...	2,542 „	19·00%	1	19	108
Lincoln, ...	2,499 „	18·31%	2	0	68
Waverley, ...	2,485 „	18·27%	1	17	70
Storm King, ...	2,429 „	15·88%	1	16	44
New Abundance, ...	2,380 „	14·89%	1	16	65
Viking, ...	2,373 „	17·61%	1	17	69
Banner, ...	2,349 „	18·91%	1	18	95
Golden Rain, ...	2,317 „	15·72%	1	13	65
Potato, ...	2,309 „	16·88%	2	4	109
Twentieth Century,	2,286 „	15·71%	1	14	42
Sandy, ...	2,279 „	16·58%	2	6	110
Thousand Dollar, ...	2,270 „	16·81%	1	18	52
Siberian, ...	2,208 „	...	1	17	23
Danish Island, ...	2,180 „	...	1	17	23
Bavarian, ...	2,063 „	...	1	18	23
White Giant, ...	2,048 „	...	1	17	20

N.B.—In all cases a uniform dressing of 1 cwt. nitrate of soda, 3 cwts superphosphate, and 2 cwts. kainit, per acre, was given.

The following statements are based on written information supplied by the experimenters in the conduct of these field trials :—

Period of Germination and Brairding.

The interval that elapses between sowing and brairding varies according to the time of sowing, the variety of oat, and the physical state of the soil at seed-time. But the weather conditions that prevail during this time have a far greater effect than any of these factors, and the difference between the various

varieties is little seen at brairding. When the oats are sown at the end of March or early in April, the normal period of germination is about 3 weeks, but in cold springs and high-lying districts it often extends to a month. In about 20 per cent. of the trials under consideration, the period of germination was less than 3 weeks. In regard to individual varieties, only a few days' interval separates the earliest from the latest at brairding time.

Early.—New Abundance; Viking; Mounted Police; Golden Rain; White Giant; Waverley.

Normal.—Potato; Besler's Prolific; Banner; Thousand Dollar; Wide Awake.

Late.—Storm King; Lincoln; Sandy.

New Abundance and Golden Rain invariably braird 2-3 days earlier than Potato, while Sandy and Storm King appear 2-3 days later than Potato.

The order in which these oats braird is never uniform, and sometimes Sandy emerges among the earliest. Much depends on the quality of the seed and on the state of the soil.

Tillering Power.

The varieties which produce abundance of straw are usually much better at tillering than those which are noted for their high grain yield. A good indication of the tillering power of the varieties under test is found in the prevalence of grasses and weeds among the sheaves at harvest time. When the oats remain thin on the ground throughout the season, and good seed has been sown, then the tillering power is weak. Weeds and grasses have more room to develop. Consequently, we find, from the reports of experimenters, that Potato and Sandy, which are the best tillerers, are much freer from weeds than new varieties like Waverley, New Abundance, and Awnless Probstei, amongst which runch and charlock often appear, and the butts of whose sheaves are grassy at harvest. It would appear, therefore, that these varieties should have a relatively thicker seeding (in absolute numbers of seeds per acre) than Potato and Sandy, especially on lea ground. But this lack of

tillering power is often an advantage, as it makes these new varieties pre-eminently suited as a nurse crop for "seeds." Being thinner on the ground, they let more light and air down to the young developing seedlings, and ensure a much better catch. But the land must be clean.

Liability to Grub and Wireworm.

Certain of these new varieties are believed by some to be more susceptible to attacks of grub and wireworm than the standard varieties, Potato and Sandy. This belief is not supported by the evidence of experimenters, and when grub and wireworm appeared among the plots all varieties were attacked impartially. The attacks of these pests are often local; patches in fields are sometimes eaten bare, and this may have given rise to the above supposition.

Earliness and Lateness at Harvest.

Nearly all the "grain bearing" oats which were made the basis of experiment in these trials are earlier at harvest than Potato or Sandy. Some of these varieties are markedly so. The four earliest kinds in order of ripening are Storm King, New Abundance, Golden Rain, and Twentieth Century. Storm King is almost invariably ripe first, yet this oat is about the last to braird, and nearly the last to shoot, but it matures quicker than any other oat after it has shot.

Sandy and Wide Awake are usually the last to ripen.

The difference in point of time at harvest between the earliest and latest of these oats varies according to soil and season, but in normal years Storm King, Golden Rain, New Abundance, Twentieth Century, and Viking, are from 10-14 days earlier than Potato or Sandy; while Mounted Police, Besler's Prolific, and Thousand Dollar are 7-8 days in advance of the standard varieties.

Early.—Storm King, New Abundance, Golden Rain, Twentieth Century, Viking, Danish Island, White Giant.

Intermediate.—Waverley, Besler's Prolific, Thousand Dollar, Mounted Police, Lincoln, Banner, Bavarian.

Late.—Potato, Sandy, Wide Awake, Awnless Probstei.

Wide Awake is usually the latest of these recently introduced oats, but it is sometimes a week earlier than Potato. The later the variety, the less uniform is the ripening; *e.g.*, Sandy and Wide Awake always contain a good many "greens" at harvest.

In reference to this characteristic—early maturity at harvest—it must be distinctly understood that much depends on the character of the seed used. Seed oats obtained from an early district, and dead ripe when cut, will usually give a much earlier crop than seed which was partially immature at harvest and allowed to ripen in the stook.

Loss by Birds, &c.

Earliness is not always an advantage, especially in districts infested with sparrows. It is seldom that a completely accurate return is obtained when several of these new varieties are grown alongside the Potato and Sandy, because their very earliness makes them subject to much loss before harvest, through the ravages of birds. Storm King, though early ripe, suffers less than New Abundance and Waverley. Most of the damage is done before complete ripeness, just when the grain is in the "milky" stage. The completely ripe grain is not so much attacked by sparrows: more is lost in this way by crows and winged game picking the grain off the stooks.

Considerable loss also takes place among the early varieties through "shedding." New Abundance is perhaps worst in this respect, but Thousand Dollar also loses considerably. Potato and Sandy, and perhaps Lincoln, suffer least of all. White Giant and Awnless Probstei shed freely in windy situations.

It is almost unnecessary to add that bad harvest weather entails much loss of grain, a loss which is proportionately greater in the case of these "new" varieties. The longer the oats remain in the stook, and the oftener the stooks are shifted, the more grain is lost. A bad harvest may result in one-fourth of the grain being totally lost.

Field mice have sometimes been reported by experimenters to have destroyed part of the plots, and in a more marked manner than the rest of the oats in the same field. This may be due to the manuring given, which is usually appreciably

heavier than that employed by the average farmer. The straw and grain being ripe earlier, and probably more appetising, apparently hold out an added inducement to the rodents to sample the "experimental" oats.

Liability to Lodge.

While the data on this point are somewhat incomplete, it would appear that the majority of the grain-bearing oats are less liable to lodge in a bad season than the straw-producing varieties. Sandy, with its long, fine straw, lodges before any of the others. Potato, as a rule, goes down early under adverse weather conditions, and in a bad autumn two-thirds of the crop is usually laid before harvest. Of the new varieties, Awnless Probstei, New Abundance, and Bavarian are apparently more liable to lodge than Thousand Dollar, Lincoln, Danish Island, Besler's Prolific, Waverley, and Banner.

Storm King stands up well in bad seasons, and Wide Awake is reported by several experimenters to have remained standing in wet and boisterous autumns.

Much, however, depends on soil, season, and manuring. If the soil is rich in available nitrogen (*e.g.*, on rich leas), or the season dull, moist, and warm, and such as to encourage a profuse growth of straw, or if a heavy nitrogenous dressing of artificials has been given, then practically any variety is liable to lodge in wet weather before harvest.

Wild game, and especially grouse, are very destructive on oats that are lodged.

Bushel Weight of Dressed Grain.

The data under this heading are fairly complete. When the grain has been dressed in the ordinary way on the farm, and no effort is made to increase the bushel weight by re-dressing, the results are fairly uniform for most of the varieties. The general average of 800 tests works out at 40 lbs. per bushel. The returns from individual experimenters show that the bushel weight may vary from 38 lbs. on poorer soils to 45 lbs. on highly farmed land. Potato and Sandy give the most uniform returns, nearly always falling between 40 and 41 lbs.

per bushel, and relatively the bushel weight of these two varieties assume the leading places in the returned schedules. Clay soils usually give a slightly higher bushel weight than other soil types, and leas than redland.

Bushel Weight of Grain.

Potato,	40·6	lb.
Sandy,	40·9	„
Banner,	40·3	„
Wide Awake,	39·9	„
Mounted Police,	40·1	„
Besler's Prolific,	40·5	„
Waverley,	40·5	„
Storm King,	40·9	„
New Abundance,	41·3	„
Viking,	39·9	„
Twentieth Century,	40·0	„
Golden Rain,	41·3	„
Siberian,	39·5	„
Danish Island,	39·2	„
Bavarian,	38·0	„
Thousand Dollar,	40·3	„
Lincoln,	40·3	„
Awnless Probstei,	39·2	„
White Giant,	38·8	„

General Average—40 lbs. per bushel.

Proportion of Light Grain to Total Grain Yield.

The proportion of light grain is very variable, depending largely on soil, season, and the thoroughness of dressing. Light and sour soils and a cold summer give a larger proportion of "seconds," while a warm, sunny season and well-tilled clays return more heavy grain. On a general average, about 10 per cent. of the total grain yield is "lights," but it may fall as low as 7½ per cent. in a very good year, and rise as high as 15 per

cent. under adverse conditions of soil and season. This statement, of course, refers only to grain dressed by the ordinary farm fanners. When the grain is put through the hummeler the proportion of seconds will be increased, while the bushel weight of the dressed grain will be considerably raised (3-4 lbs). Hummeling, however, often spoils the grain for seed purposes.

Weight of Grain compared with Weight of Straw.

The ratio of the weight of grain to the weight of straw is, for the new varieties—1 grain to 1·7 straw; but with Potato the ratio is—1 grain to 2·1 straw; and in the case of Sandy—1 grain to 2·7 straw. These are average figures, and are not to be regarded as in any way constant. In one case the grain yield has been returned as six-sevenths of the weight of straw, while in another the grain yield was seventeen-twentieths of the weight of straw. In both of these cases the experiment was most carefully conducted, and accurate weighings made at threshing. These instances of high grain yield in relation to straw are, however, rather exceptional.

Quality of Straw of Different Varieties.

The weight of evidence of the experimenters establishes the fact that Potato and Sandy produce the finest quality of straw for fodder purposes. With regard to the new varieties, the evidence is somewhat conflicting, but in no case has it been shown that stock will not readily consume such straw. The appearance of the straw of the new varieties is often against it, as it has a tendency to be strong and firm, suggestive of coarseness. It has sometimes been reported as being brittle. The quality of the straw is largely governed by soil and season, but, other things being equal, the best quality is given by Besler's Prolific, Viking, Lincoln, Mounted Police, and Waverley. Wide Awake and Storm King very often give a coarse straw.

Adaptability of Variety to Soil.

So far as can be concluded from the schedules, no variety can claim absolute priority on any particular class of soil. A

general statement, however, based on the "majority report" of the experimenters, can be made with some degree of precision.

Besler's Prolific, Wide Awake, and Mounted Police do well on nearly any type of soil, though Wide Awake does relatively better than the other two on poor soils. These three varieties are perhaps the most reliable of the new oats, and even comparative failures are rarely recorded. Lincoln gives a good return on heavy to medium soils, while Banner and Waverley —especially the latter—give relatively better returns on the lighter classes of soil. Viking does well on good soil and in good seasons, but suffers more than the three first-mentioned under adverse conditions. New Abundance is similar to Viking in character. Its real return is not often realised, on account of its earliness and the consequent loss it suffers from birds. Thousand Dollar is often a disappointing oat, and cannot be recommended.

Potato and Sandy can always be depended on, and on dairy farms especially, where the straw is largely used for fodder, and even more stress put on it than on the yield of grain, these two varieties can be confidently recommended. The grain yield of Potato, while never rising so high as the best of the new varieties, is surprisingly good on whinstone soils, and in circumstances when the grain is well ripened before harvest. Sandy has proved very suitable for high-lying and exposed situations.

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The West of Scotland Agricultural College.

FOOD PRODUCTION

IN

COTTAGE AND ALLOTMENT GARDENS.

BY

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Superintendent, Horticultural Department.

GLASGOW, 1916.

INSTRUCTION IN HORTICULTURE.

EXTENSION LECTURES AND DEMONSTRATIONS.

The Governors are prepared to consider applications for the services of the Lecturers in Horticulture, not only for the delivery of Lectures, but also for visits to orchards and gardens, with a view to giving advice as to their improvement.

The services of the Lecturers are given free, and the travelling and other personal expenses paid, but the Local Committee is expected to make all necessary arrangements for the Lectures and Demonstrations, including advertising, use of Schoolroom or Hall, &c.

Evening Classes in Horticulture for young Gardeners and others interested in gardening are held during the winter session at the Agricultural College, Blythswood Square, Glasgow. Particulars of these and other classes may be obtained from the Secretary.

Copies of this Bulletin may be had on application.

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FOOD PRODUCTION IN COTTAGE AND ALLOTMENT GARDENS.

INTRODUCTORY.

The following notes are prepared in response to numerous requests for definite information on how to make the best use of our gardens during the abnormal conditions created by the present war.

Vegetables, fruits, and flowers were never cheaper than during the early stages of the war. This was due to the abundant harvests of 1914 and the lessened demand for these articles, people at first being reluctant to purchase anything except bare necessities. It is desirable, however, to look well ahead to ensure that an adequate and constant supply of garden produce be forthcoming during the continuance of the war.

The people of this country, especially those living in towns, do not make use of vegetables and home-grown fruit to the extent that they might, nor do they use such a variety as is desirable from an economical and health-giving point of view.

It is to be hoped that much more attention will be paid to proper and economical methods of cooking vegetables and fruit, also to the importance of greater variety, since, owing to the war, other articles of food are high in price. All who possess gardens should endeavour to cultivate them to the fullest extent, and thus produce as much as possible of the most serviceable kinds of garden crops, not only on economic grounds, but also as a means of conserving our national resources.

Well-cropped gardens and allotments are a valuable national asset, and if they are to contribute their full and proper share to the country's food supplies, a more intensive system of cultivation and cropping must be practised than has hitherto been the rule. In any scheme of planting, the growers should bear in mind the vagaries of the climate and the kind of soil to be dealt with.

COTTAGE GARDENS.

Gardens attached to cottages are not all equally adapted for the production of garden produce, as they vary very much regarding size, aspect, and kind of soil.

Some cottage gardens are far too small to be of much service in the production of fruit and vegetables; but with a good-sized plot, ranging from ten to forty poles, it is possible to grow a good deal of useful produce.

The cottage garden is an ideal place for the cultivation of flowers, fruit, and vegetables, being more convenient for the worker than an allotment, more private, and more secure against trespass.

The portion of the garden in front of the cottage is usually devoted to flowers, with often a few shrubs and roses or other climbing plants on the walls or porches. In some cases a small grass plot is laid down, which greatly adds to the appearance of a cottage or villa. The back garden is generally set apart for the cultivation of vegetables and fruits, with a flower border for herbaceous perennials and choice annuals along the sides of the paths.

Where there is a shady corner, it may be made attractive and interesting by constructing a rockery or fernery.

ALLOTMENT GARDENS.

The term "allotment" is applied to a small plot of land rented to cottagers or to artizans of towns and cities, who have other regular work, and cultivate the plots in their spare time.

Allotments are usually in groups, a field or spare piece of land being divided into a number of plots of different sizes. Rules are drawn up for the observance of the plot-holders, so as to ensure harmony in working the plots. Space will not admit of a full code of rules being given here, but it would be well in all cases for a rule to the following effect to be included, viz., that holders having certain infectious plant diseases or garden pests on the plots, such as wart disease of potatoes, finger-and-toe disease of turnips and cabbages, American gooseberry mildew, and big bud on black currants,

When fresh ground is broken up, it should be dug two spades deep. This is known as double digging or bastard trenching. Skim off the turf about two inches deep from the first trench, which should be about twenty to twenty-four inches wide. Lay the turf aside, and take out the top spade depth of soil, placing it in a heap beside the turf. Next dig over or break up thoroughly the subsoil, and on this turn upside down the turf layer from the second trench. The top spade depth of the second trench should be turned over on the turf to fill up the first trench. Continue this process until the whole area has been dug two spades deep, keeping the top soil still on the surface. Use the turf and soil from the first trench to level up the last in finishing the work.

It is customary at the time of digging land to incorporate any garden refuse, such as leaves, road scrapings, ditch parings, weeds, or materials from a compost heap; failing any of these, a dressing of rotted manure may be forked into the ground at the rate of three barrowloads per pole, some time after the digging has been done.

In the case of land that has been lying waste or has become full of noxious weeds, such as couch-grass, horsetail, coltsfoot, bishopweed, docks, or dandelions, care should be taken to pick out the roots or underground stems of these during the process of digging, for if dug in they will grow again. Other weeds, of an annual nature, such as chickweed, groundsel, etc., may be dug in, as they quickly rot, and thus add to the fertility of the soil.

PATHWAYS.

In a small garden or allotment the main pathway should be three feet wide. From the main path, alleys about twelve or eighteen inches wide may run at intervals, where considered necessary. They are useful for getting between the different beds or borders, and save these from being trampled upon too much.

Materials for Pathways.—In the case of allotment gardens, the natural soil trodden down hard is generally sufficient for a pathway, but for constant use pathways should be made of

harder material to walk on, and at the same time be so porous that even heavy rains soon pass away from them.

A good, serviceable pathway may be made as follows :—

Dig out the pathway to a depth of 6 to 12 inches, spreading the soil thus obtained evenly over the adjoining beds or borders.

The pathway may then be made up with broken bricks, stones, or clinkers, finishing off the surface with fine cinders or gravel.

The edges of the plots can be kept in order by using 4-inch deal boards (treated with creosote or tar), or bricks placed in a slanting position. Stones, slates, or tiles may also be used. Some plot-holders or cottagers favour living edgings to their paths, such as box, thrift, pink, rockfoil, London pride, stonecrop, snow-in-summer, &c.

MANURING GARDEN PLOTS.

Manures may be classified as (*a*) artificial and (*b*) natural.

Artificial manures are those which have come into use since about 1840. They are obtained from the manufacturer or merchant.

Natural manures have been in use from time immemorial; being home or farm products, they do not generally pass through the manufacturer's hands.

(*a*) Artificial manures may be grouped as follows :—

(1) Nitrogenous manures, containing nitrogen, such as nitrate of soda, sulphate of ammonia, lime nitrate, and nitrolim.

These manures tend to promote the growth of stem and leaf, and should be used very sparingly as top dressings for growing crops, at the rate of $\frac{1}{2}$ oz. to 1 oz. per square yard; showery weather being the best time to apply. Care should be taken to prevent the manures coming in contact with foliage more than is possible.

(2) Potash manures. These manures tend to increase the quality and flavour of vegetables and fruit.

will be called upon to take proper steps to eradicate these by burning or other approved method.

Plots are frequently placed at the disposal of workers by public-spirited landlords. In some cases a number of resident ratepayers combine together to form an association or committee, and by approaching a farmer are often enabled to obtain a suitable piece of land for the formation of garden plots.

In case of difficulty in procuring land for this purpose, six ratepayers of a district may petition the Parish Council to provide suitable land for allotments. If the Parish Council fails to provide the land, the County Council should then be petitioned, and, if unsuccessful, finally the Local Government Board. Allotments obtained in this way are usually managed by an Allotment Committee of the Local Authority.

The size of allotment plots varies very much, ranging from four poles to forty poles. A useful size is one of about ten poles (300 square yards). The rent charged for these plots varies from 4d. to 1s. per pole.

The disadvantages of allotment gardens when compared with cottage gardens are—(1) distance from the home of the worker; (2) less privacy; (3) less security for choice flowers or fruits that the holder might wish to grow.

Allotment gardens are more common in England than in Scotland at the present time, but much greater interest than formerly is now being taken in this type of garden.

Allotment holders with limited experience should proceed cautiously at first, as it is found that the climate and soil vary very much in different districts. The methods of cultivation, manuring, kinds and varieties of crops to be grown, must be adapted to meet local conditions; intelligent cultivation and suitable manuring will, however, overcome many difficulties in this respect. Where the allotment is of considerable area, the holder usually grows both for market purposes and for supplying the needs of his family. In this way the plot is a source of income; but it must be remembered that the small grower has to compete in the open market with the large grower.

VACANT BUILDING PLOTS.

In some of our large towns and cities it may be difficult to obtain land for allotment purposes, and at the commencement of the war all sorts of fanciful schemes were advocated to produce garden crops, such as the planting of window-boxes and flower beds with vegetables. It was also suggested by some that lawns, tennis courts, and public parks, should be broken up for the same object.

It will be time enough for this when all other means of obtaining land for food production have failed. In our towns and cities are to be found many vacant plots ultimately intended for building purposes, which in the meantime could be fenced, sub-divided, cultivated, and utilised for the production of food.

To make such a scheme a success, a few enthusiastic persons of a philanthropic turn of mind should combine and form an Association. The business of the Association would be to make arrangements with the owners of any vacant or waste land, and take over the same until actually required for building on; also to fence, level, and divide the land into plots of a convenient size, and endeavour to get suitable tenants to take up plots.

Such a scheme ought to be self-supporting after the initial outlay in fencing and first digging are met. If the Association could obtain subscriptions, or a grant from the Common Fund of the Town Council, for such a laudable purpose, then not only would many vacant pieces of land be turned to good account, but they would be the means of largely increasing our food supplies.

CULTIVATION OF THE SOIL.

Having obtained a plot of land, the first thing to do is to break up the soil. This is usually done in the autumn, winter, or spring. It would be difficult to over-estimate the beneficial effects of deep cultivation, and laying the soil up to the action of frost.

Any of the following liquid manures are suitable for watering pot plants, greenhouse crops, and outdoor vegetables, fruit, and flowers :—

15-20 lbs. of poultry manure to 30 gallons of water
" pigeon " " " "
" sheep " " " "
" horse " " " "
" cow " " " "
" soot " " " "

1½ lb. of Peruvian guano manure to 30 gallons of water.

1½ lb. of superphosphate and ½ lb. of nitrate of soda to 30 gallons of water.

Lime exists in soil as carbonate of lime. It is extremely valuable for clay soil, sour soil, peat soil, and heavily manured land. An application of lime will benefit nearly all crops. The old practice was to apply lime every 6 or 10 years, but more frequent applications are now the rule. Ten to twenty cwt. per acre every three years is considered a light dressing, and one to two tons or more during the same period constitutes a good dressing. For garden purposes, a half to one bushel per pole, or a half to 1 lb. per square yard, is the quantity usually applied.

Soot is a very valuable manure, and may be dug into the soil (½ bushel per pole) or used as a top-dressing for many crops, such as onions, carrots, beet, greens, &c. Sprinkled over seedlings, it acts as an insecticide, keeping away various pests (snails, caterpillars, &c.). Soot is sometimes of very poor quality indeed; that of a light velvety or fluffy nature being best.

Manures generally suited for light soils.—Nitrate of soda, nitrate of lime, nitrolim, kainit, muriate of potash, salt, superphosphate, bone meal, fish meal, leaf mould, well rotted farmyard manure.

Manures for heavy soils.—Sulphate of ammonia, sulphate of potash, raw bones, steamed bones, basic slag, lime, farmyard manure, stable manure, leaf mould.

Mixture suitable for light land.—20 tons rotted farmyard manure, 6 cwt. superphosphate, 1 cwt. muriate of potash, and 2 cwt. nitrate of soda per acre. In some cases it may be advisable to increase the amount of farmyard manure and use smaller quantities of artificial manures.

Mixture for heavy land.—15 tons stable manure or farmyard manure, 6 cwt. superphosphate, 1 cwt. sulphate of potash, and 2 cwt. sulphate of ammonia, per acre.

WHEN TO APPLY MANURES.

(1) Autumn or winter. All natural manures, *e.g.*, farmyard manure, leaf mould, &c.; also lime, kainit, basic slag, bones, and gas lime, may be applied in the autumn or winter.

(2) In the spring, sulphate of ammonia, sulphate of potash, superphosphate, and bone meal, may be applied before planting or sowing.

(3) During spring and summer, top-dressing in small doses, every week or ten days—during showery weather if possible—of such manures as nitrate of soda, Peruvian guano, nitrate of potash (saltpetre), and liquid manures of all kinds, may be applied to growing crops.

HOW TO APPLY MANURES.

Natural manures are dug into the soil, whilst basic slag, kainit, lime, bone meal, and superphosphate, may be applied to the surface and forked in.

Sulphate of ammonia, sulphate of potash, nitrate of soda, Peruvian guano, superphosphate, &c., may be used as top-dressings, and should be accurately weighed and spread evenly to ensure good results.

HOW TO OBTAIN MANURES.

Cultivators should take care of all waste products, such as animal manures, leaf-mould, and soot, for application to the soil.

Examples.—Kainit may be applied in winter at the rate of 4 oz. per square yard, being forked in the surface soil after the digging has been done.

Sulphate of potash may be used at the rate of 1 oz. per square yard, at the time of planting, or as a top dressing during the growth of the crop.

Wood ashes contain 5 to 10 per cent. of potash, and are very valuable for digging in the soil, or as a top dressing for many crops.

For many years we have been dependent on Germany for our chief supplies of potash manures; but these being temporarily cut off, we must use some substitutes such as wood ashes, and also make as much use as possible of farmyard and stable manure, liquid manure, &c. All prunings, &c., should be gathered together and burned, and the ashes taken care of until required for use.

Lime and salt, to a certain extent, will liberate potash already existing in the soil. Seaweed or wrack, in districts near the sea, should be used very largely as manure, as it supplies much potash.

(3) Phosphatic manures. These manures promote fruitfulness and early maturity. The principal kinds are :—

Superphosphate, which is fairly quick acting, and may be used at the rate of 2 to 3 oz. per square yard, as a top dressing for growing crops; or it may be forked into the soil or placed in the drills before planting or sowing.

Bone meal and bone flour are also good sources of phosphate, and may be used at the rate of 3 to 4 oz. per square yard as top dressing, or worked in the surface soil before planting.

Basic slag should be used quite freely for most garden soils, and for most crops, at the rate of 4 to 8 oz. per square yard.

(4) General manures.—These contain nitrogen, potash, and phosphates, thus constituting complete manures. The

value of a general manure depends on the amount present of each of these substances. Proprietary manures, so widely advertised for general purposes or for special crops, belong to this group. General manures usually give good results, so far as a well-balanced growth is concerned, but many are sold at prices which will not allow of their use on a large scale; or, if the price is low, the quality may be low also, as mixing, compounding, and advertising have to be paid for.

The principal kinds belonging to this group other than the proprietary manures are Peruvian guano, Canary guano, fish guano, rape dust, spent hops, &c. These may be used at the rate of 2 to 4 oz. per square yard.

(*b*) Natural manures are complete manures, supplying nitrogen, potash, and phosphates, and may be applied with good results. Containing, as they do, a large quantity of organic matter, their use has a beneficial effect on all classes of soil. The principal kinds are farmyard manure, stable manure, poultry manure, pig manure, seaweed, &c. These manures may be applied at the time of digging or at the time of planting, at the rate of 3 to 4 barrow-loads per pole.

Liquid manure may be made from cow, horse, sheep, or poultry manures, or the liquid drainings from cowsheds, stables, or manure heaps may be utilised in a dilute state. Peruvian guano, and, indeed, almost any kind of artificial manure, may be dissolved in water and applied during showery weather. Should the soil be very dry, a soaking of water, given shortly before, will prepare the way for the solution, which will diffuse more readily through the moist soil, and as the roots take it up with the soil moisture, there will be no damage whatever to the plant. Weak doses should be the rule, and always with judgment as to the quantity to apply. Liquid manure may be applied to fruit crops, most garden crops, and pot plants, and is particularly valuable on light soils in dry seasons, if plenty of water is also used. As far as possible, care should be taken to keep the manure from coming in contact with the foliage of the plants.

Artificial manures, especially proprietary kinds in small quantities, may be obtained from seedsmen, nurserymen, and stores; but the cost is fairly high, which prohibits their use to a great extent among cottagers and allotment-holders.

Cottage garden or allotment associations and horticultural societies would be doing a great service to their members if they would purchase some of the principal kinds in bulk in the original bags, and retail in small quantities, among those requiring them, at a little over cost price. This co-operation among plot-holders and cottagers might be extended, thus enabling them to obtain lime, plant washes, fencing material, and garden implements, especially some of the expensive kinds, such as a knapsack spraying machine for spraying potatoes, roses, &c. The latter, costing from 40s. to 50s., could be purchased by the society, and let out at a nominal cost to members.

TILLAGE AND OTHER OPERATIONS CONNECTED WITH THE SOIL.

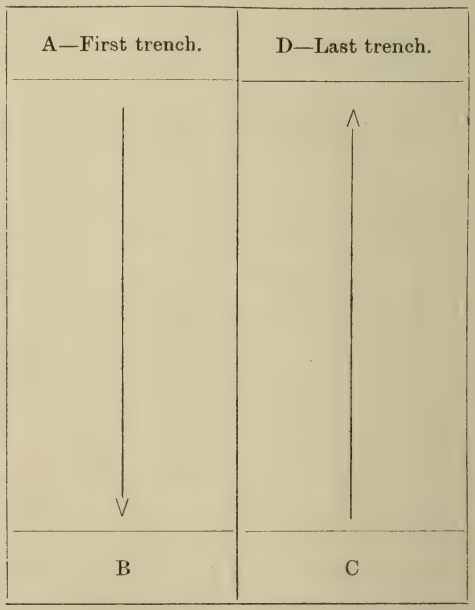
Drainage.—It is important that water should pass freely through the soil, which would otherwise become water-logged, cold, and sour. Bacteria useful to plant life—excepting, of course, marsh and bog plants—can only flourish in well-drained soil, and by their presence promote a healthy growth of the roots. Soils should be of such a nature that they can absorb and retain moisture, to replace that taken by plants or lost through evaporation.

Sand or sandy loams do not generally require draining, as they cannot hold much moisture; in fact, sand has the least water-retaining or absorbing power of any soil. The water-retaining capacity of clay and peat is respectively five and six times greater than sand. Waterlogged soil requires an enormous amount of sun heat to warm it in the spring, consequently crops are late when grown on such soil. Drainage makes the soil warmer and drier by removing superfluous water, thus enabling atmospheric air to take its place.

Cultivation.—Digging is the common method of soil cultivation practised in gardens.

1. *Simple Digging* consists in turning the soil to the depth of a spade, *i.e.*, 9 to 12 inches, or one " spit " (spade) deep, and is performed in the following manner :—

Commence operations at the end of the site to be dug by opening a trench one foot wide and a " spit " deep. If the portion to be dug is narrow, the soil from the first opening will have to be wheeled to the opposite end of the site, and deposited there in readiness for filling in the last trench. Should, however, the land be sufficiently wide, it will be found convenient to divide it into two portions, as shown in the sketch. In this case the soil from the first trench A should be placed alongside the last trench D, and when B is dug the soil from C will be utilised for filling B.



Simple Digging.

2. *Double Digging or Bastard Trenching.*—In this case the soil is worked two " spits "—about 18 inches—deep, the subsoil being retained in its original position.

Open a trench A a " spit " deep, and two spades (about 18 inches) wide, shovel out the " crumbs "—the loose soil—

and wheel the whole to a position convenient for filling in the final trench. The subsoil B should then be forked over, and the soil from C turned over on top of it, levelling off with the " crumbs " prior to forking the subsoil D.

A	C	Surface soil.
B	D	Subsoil.

Double Digging.

Raking is a means of loosening the soil, disturbing weeds, and breaking up lumps or clods, and is useful for levelling and for obtaining a fine surface.

Raking is by no means so simple as it looks, requiring considerable practice and dexterity of action. It is not necessary or desirable to remove all the stones from the surface, but only the largest.

Hoeing or other surface cultivation is of great advantage to growing crops. Weeds are killed and checked. The ground is kept more moist, air admitted, and a fine surface tilth formed which prevents cracking and loss of moisture. Crops make greater progress, mature earlier, and generally command a better price, which more than compensates for the extra cost of labour incurred.

Mulching, or top dressing soil with manure, leaf mould, spent hops, grass clippings, &c., is practised on light soils, thus restricting the evaporation of moisture from the soil during dry weather. By this means the roots are kept cool and moist, watering is saved, and the soil is manured. If applied in winter to newly planted trees or shrubs, the roots are protected from frost by the checking of the radiation of heat. When the soil is at, or near, freezing point, the plant's roots cease to take in water, so that if evaporation is at the same time going on from the surface of the stem or leaves, there is nothing to repair the loss, and the plant may dry up completely and be killed.

Earthing up plants with soil encourages a greater development of stem or leafstalk, and by blanching them, causes the plants to be more tender and succulent; examples—celery, leeks, seakale, and to a certain extent asparagus. Peas, beans, cauliflowers, and cabbages are sometimes earthed up to keep the plants firm in the ground and encourage the production of lateral roots. Potatoes are earthed up (1st) to prevent frost from damaging the tender shoots, (2nd) to encourage more underground stems to arise from the haulms and thus add to the yield of the crop, and (3rd) to prevent the tubers greening by exposure to light.

Thinning or singling plants such as turnips, carrots, onions, parsnips, beet, or spinach, results in larger and more uniform produce, better suited for marketing, and consequently realising a higher price. Early thinning prevents the attacks of insect pests and damage to the roots, and all thinning is best done in showery weather.

Transplanting is practised with leeks, onions, cabbage, greens, cauliflower, lettuce, &c., but not with tap-rooted crops, such as carrots, parsnips, beetroots, and turnips. It is best done when the soil is moist, or in showery weather. Should hot dry weather immediately follow, give the soil a good soaking of water at intervals until the plants are established. The soil should be made firm about the roots after planting.

Watering, if deemed necessary in spite of hoeing, mulching, &c., should be done by giving a thorough soaking to reach all the roots, as this encourages them to go still deeper. A slight or surface watering tends to keep the roots near the top, and, unless persistently followed up, results in more harm than good to the plants. Watering is best done in the evenings. This allows plenty of time for the water to soak into the soil, and the plants are able to fortify themselves against the next day's drought. Moreover, growth is probably more active during the night. It is better, however, to water seedlings in the early morning. If done at night, the moisture attracts slugs and woodlice, and many seedlings are destroyed.

Shortly after watering, it is advisable, on certain soils, to hoe the surface, to prevent the formation of a crust which cracks when thoroughly dry.

Weeding.—This operation in the case of young weeds is best done by means of the Dutch hoe, or if the weeds are very large or occurring among seedlings, they should be removed by hand. Deep-rooting kinds, or those with underground stems like couch grass, coltsfoot, horsetail, bishop-weed, bind-weed, &c., should be removed by means of a fork or spade, and afterwards burned.

SEED SOWING.

Seeds may be sown broadcast by hand over the surface of the soil, which should then be raked or harrowed to cover the seeds. In garden practice, however, seeds are generally sown thinly in drills, drawn by a hoe or rake, at depths varying from ¼ inch to 3 or four inches, according to the size and kind of seed and also the character of the soil.

Soil for the reception of seed should be even and firm, with a fine loose surface, not pasty or sticky, nor dust dry. After sowing, particularly on light land, press the surface down with the back of the spade, to conserve the soil moisture.

It is necessary to sow at the proper depths, placing small seeds near the surface, and larger seeds proportionately deeper; and in all cases to sow somewhat deeper than the average in a light sandy soil, and nearer the surface in a heavy clay.

Thin sowing should be the regular practice, and afterwards early thinning out, not only from an economical point of view, but in order to get strong, sturdy plants. The aim should be to obtain a strong, vigorous germination in the first instance, and later to avoid overcrowding, as that is ruinous to young plants.

Appended is a seed table showing the depths at which to sow in a medium soil, and the approximate quantities of seed required :—

Seed Table.

Kind of Seed.	Quantity-Length in Drills.	Depth to Sow.	Distance apart—	
			Rows.	In the Rows.
Broad Beans, -	1 pint to 50 feet,	3-4 ins.,	30 ins.,	6-8 ins.
French Beans, -	1 „ 170 „	2-3 „	24 „	6 „
Runner Beans, -	1 „ 35 „	3-4 „	6 feet,	6-8 „
Early Peas, -	1 „ 65 „	2 „	2-3 „	—
Main Crop Peas,	1 „ 80 „	2-4 „	4-6 „	—
Turnips, - -	1 oz. to 200 „	1 in.,	12 ins.,	6-8 ins.
Carrots, - -	1 „ 250 „	1 „	12 „	6-8 „
Parsnips, - -	1 „ 180 „	1 „	15 „	9 „
Beet, - -	1 „ 50 „	1¼ „	15 „	9 „
Onions, - -	1 „ 170 „	1 „	12-24 „	6-9 „
Leeks, - -	1 „ 150 „	1 „	12-24 „	6-12 „
Celery, - -	½ „ 6 sq. yds.,	¼ „	4 feet,	9 „
Parsley, - -	1 „ 200 feet,	¼ „	12 ins.,	6-8 „
Radish, - -	1 „ 60 „	1½ „	12 „	—
Lettuce, - -	¼ „ 140 „	¼ „	12 „	9-12 ins.
Cabbage Family,	1 „ 150 „	¾ „	24 „	18-24 „

Birds are very fond of seedlings, and give a lot of trouble, especially in hot weather, the tender and sweet young sprouts being very palatable to them. Freshly mown short grass may be scattered over the surface of seed beds, or black thread fixed over the rows will be found a useful protection from

birds. The thread may be fixed to pegs six to nine inches in length, these being pushed about three inches into the ground and the thread stretched tightly from end to end, about three inches above the soil.

Mice, too, sometimes give trouble, especially in the case of large seeds like peas, beans, and the seeds of trees. As a protective measure, damp the seeds and shake them up in red lead, or soak them in paraffin oil for an hour before sowing.

Seedlings of vegetables and flowers are often attacked by slugs. The damage, however, may be greatly reduced by applications of soot, or fine slaked lime in the form of powder, over the plants at frequent intervals. In the case of seed sown in pots or boxes, it is desirable that the soil be sterilised by pouring boiling water over it. This kills all insects and insect eggs, otherwise tiny slugs and snails are apt to hatch and destroy the seedlings.

THE ROTATION OF CROPS.

Rotations are the result of experience, and by rotation of crops is meant the cycle of cropping adopted whereby large quantities of produce are obtained whilst the fertility of the land is maintained.

It is well known that, unless special precautions are taken, the same kind of crop cannot be grown successfully on the same land for many years in succession. Different crops require different plant food and in different proportions—what is left by one crop may be useful to another.

Some plants are deep rooters, others are surface rooters. Some crops occupy the land for a long period, *e.g.*, rhubarb, seakale, asparagus, strawberries, and fruit bushes; others only for a few weeks—lettuce, peas, spinach, radish, &c.

Some crops are a good preparation for others, *e.g.*, celery for onions, beans or clover for wheat, potatoes for most crops. Deep rooters enrich the soil for surface rooters.

Rotation affords better opportunities for cleaning the land, for checking the attacks of insects and plant diseases. In addition the crops are more vigorous and less manure is

required. Crops of the same family should not, as a rule, follow one another.

Rotation in gardens may extend to two, three, or four years, and it is important that a record of actual cropping be kept.

Examples of crops which may follow or succeed one another.—Peas and beans may follow root crops or the cabbage family, or come before celery, leeks, lettuce, turnips, or greens. They collect and store nitrogen, and respond to dressings of potash phosphates and lime.

Root crops, such as carrots, parsnips, beet, salsify, and scorzonera may follow celery, onions, lettuce, cabbage, or leeks.

They like deep rich land which has been well manured for the previous crop. Phosphates, soot, salt, and lime are beneficial to root crops, but fresh farmyard manure should on no account be used.

Cabbage crops may follow peas, beans, lettuce, potatoes, onions, celery, and root crops.

This class requires liberal manuring, and is benefited by the use of nitrogen, potash, and phosphates.

Potatoes may succeed any crop—cabbage crops, peas, beans, &c.

Strawberries do very well after potatoes.

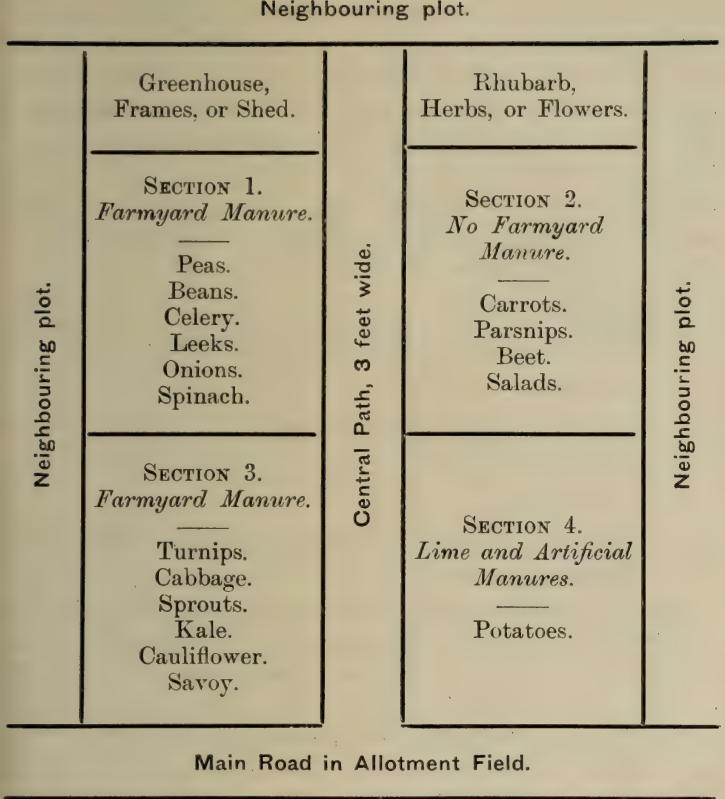
EXAMPLE OF CROPPING AN ALLOTMENT OR COTTAGE GARDEN FOR A FOUR-YEAR'S ROTATION.

The size of the plot is 10 poles (300 square yards), length 60 feet, breadth 45 feet. Provision is made in the plan for a greenhouse, frame, or shed; also for rhubarb, herbs, or flowers.

Additional flower borders, about 3 to 4 feet wide, may be arranged along the sides of the central path.

The remainder of the plot may be divided into four more or less equal sections, and the crops grouped as shown on the plan. It is advisable to arrange that the rows of vegetables run approximately north and south.

Each year the position of the various groups will be changed. A period of four years will elapse before the same crops will be planted again on the same section.



PLAN OF AN ALLOTMENT, 60 FEET BY 45 FEET, SHOWING FIRST YEAR'S CROPPING.

THE CULTURE OF VEGETABLES, SALADS, AND HERBS.

VEGETABLES.

THE POTATO delights in a good friable loam, well drained, and well worked. Clay soil should be trenched or double dug in autumn or winter, and road scrapings, sand, leaf mould, or burnt garden refuse worked in. Light land should have plenty of well-rotted manure applied.

The soil should be well forked over in March to sweeten it,

and the potatoes planted about the end of April when the soil is fairly dry. The sets may be planted 4 inches deep, and 12 to 18 inches apart, the rows being 2 feet 3 inches from one another. Sprouted sets are more satisfactory than unsprouted sets. Sprouting may take place in shallow boxes kept in a light, dry, but frost-proof shed. A change of seed is very desirable every two or three years. When the shaws (stems) are six inches high, the soil may be loosened by means of a fork, and the plants earthed up.

Early varieties:—

Epicure, May Queen, Midlothian Early, Ninety-fold.

Second Earlies:—

Abundance, British Queen, Conquest, Great Scot, Windsor Castle.

Late varieties:—

Arran Chief, Baronet, Dalhousie, Dobbie's Prolific, Golden Wonder.

Green Peas require plenty of space, and soil in a high state of cultivation. The seed may be sown, 3 to 4 inches deep, from January to July, for a succession of crops over a long period, or from March to June in cold localities. Deep trenches should be dug in order that plenty of manure may be applied. The soil displaced during this operation, after being returned to the trenches, must be trodden firm. Where mice or birds are troublesome, the rows may be covered with fine cinders and frequently sprayed with paraffin emulsion or some other strong-smelling insecticide. Or pea guards may be used to keep away birds. Earthing up of the young plants must be attended to as soon as they attain a height of 4 to 6 inches.

Early staking is necessary in the case of tall growers. During dry weather the plants may be mulched with short manure or lawn clippings, and watered freely.

Varieties Recommended:—*Dwarf kinds* (with or without short sticks)—The Sherwood, 1 foot; English Wonder, 1 foot; Ameer, 2½ feet; Bountiful, 2½ feet.

Tall kinds (3 to 4 feet)—Gradus, The Bell, Gladstone, and Eureka.

Scarlet Runner Beans are an important crop in the south. They require similar culture to green peas, and may be sown in May, 4 inches deep and 6 inches apart. They will climb up tall sticks, trellis, wire-work, or strings, or may be grown without support by pinching the growing shoots when 2 to 3 feet long.

Varieties:—Scarlet Emperor, Sutton's Best of All, &c.

Kidney, Dwarf, or French Beans require the same general treatment as for scarlet runners, with the exception that no support is necessary. Sowings for a succession may be made from May to July.

Canadian Wonder is a good variety.

Broad Beans are very hardy, and usually find a place in every garden, but are not appreciated to the same extent as green peas.

Seeds may be sown from February to March or April, 4 inches deep and 6 inches apart. It is advisable to pinch the tips out of the plants as soon as the lower pods are forming.

Short-podded varieties:—Broad Windsor and Green Windsor.

Long-podded varieties:—Bunyard's Long Pod, Mammoth Long Pod, &c.

Turnips do best in good, rich, cool, moist soil, with a supply of phosphates such as bone meal, basic slag, or superphosphate.

Seeds may be sown from April to June for a succession of tender roots. Very early sowing will cause the plants to "bolt," especially in the north. Sow thinly in drills 1 inch deep and 1 to 1½ feet apart, and thin out when large enough to handle.

There are some splendid varieties in cultivation, such as Early Milan, Snowball, Golden Ball, &c.

In the north swede turnips are greatly in request during the winter. These are hardy, and keep well for a long period. Garden varieties of the swede are very good for this purpose.

Cabbage for spring and early summer use may be sown on a nicely prepared seed bed about the middle of July.

M'Ewan's Early (Vanack) is a good kind for Scotland, whilst Sutton's April, Harbinger, and Flower of Spring are worthy of trial.

Cabbage for summer, autumn, and winter use are obtained by one or two successive seed sowings, in April or May, on a sheltered and well-prepared seed bed, and the seedlings transplanted in May, June, or July, when the weather is suitable.

Suitable varieties:—Sutton's Imperial, Maincrop, Winningstadt, Early York, &c.

Savoy cabbage, broccoli, Brussels sprouts, curly kale (borecole), asparagus kale, cottagers' kale, sprouting broccoli, and coleworts may all be sown in April and planted out when the weather is favourable, or when the land is ready for their reception. They require good, firm, not over rich soil, and may be planted 18 inches to 2 feet apart, with 2 to 3 feet between the rows, according to kinds.

Cauliflowers are gross feeding plants, and therefore require deeply trenched soil with plenty of manure. The addition of one bushel of lime per pole, before planting, will be beneficial to the plants. When grown on poor ground growth is slow, and the plants are liable to "button," *i.e.*, to form small heads, prematurely. This may also occur if the plants have received a check in the young state.

Seeds are sometimes sown in the autumn, wintered in frames, and planted out in April for early crops. Or seed may be sown in heat from February to March, or outdoors on a warm sheltered border in April, for providing "heads" for summer and autumn use. Young plants are available from shops in spring for planting.

Varieties:—Early—Sutton's First Crop, Early Erfurt. *Late*—Veitch's Autumn Giant, Webb's Peerless Purity.

Onions.—Every allotment holder and cottager delights in growing large onions. Their successful cultivation, however, depends upon a variety of circumstances, such as well manured, deeply worked soil, and facilities being available for bringing on the seedlings in readiness for planting out in April. Firm soil is essential to good growth. Seeds are sown in pots or

boxes, under glass, from January to March, the seedlings pricked out into boxes of rich soil, kept near the glass, and eventually gradually hardened off preparatory to being planted out. Seeds may also be sown outdoors from March to April, but it is only in warm districts that outdoor sown onions grow to a large size. A good useful crop may be obtained by outdoor sowing if the ground is treated liberally, and plenty of soot, powdered lime, or some soil fumigant such as "Killogrub" or "Vaporite" worked into the soil before sowing, and frequent dustings of soot given when the seedlings appear. The seedlings should be thinned to about 6 to 9 inches apart, and the thinnings may be utilised for transplanting or for salad purposes.

Young onion plants from hothouses or frames may be planted 9 to 12 inches apart, 14 inches being allowed between the rows. A trowel will be found useful for this operation, and care should be taken to spread out the roots, to keep the upper half of the young bulb above the surface of the soil, and to press the soil firmly round each. Transplanted onions are less liable to the attack of the onion fly maggot than those raised in the open.

Constant attention to the seedlings by frequent dustings of lime or soot, or spraying with some insecticide, will do much to prevent egg laying by the onion fly. The use of bone meal, superphosphate, or potash, will assist the plants.

The bulbs are lifted, dried, and stored in a dry, frost-proof place until required for use.

Reliable varieties for general cultivation:—Ailsa Craig, Bedford Champion, Carter's Record, Sutton's A 1, James' Long Keeping, Cranston's Excelsior.

Onion sets, i.e., small onion bulbs of the previous year's growth, in a dry dormant condition, are now obtainable from seedsmen from 1s. to 1s. 6d. per pound. One pound will contain about 400 of these small bulbs. They may be planted in March, 6 to 8 inches apart, on well prepared ground, in the same way as shallots. Very good crops are produced in this manner, and usually free from the onion fly maggot. The bulbs do not keep long.

The Shallot is a perennial, and its bulbs are planted in March, 6 to 9 inches apart, being lifted when the leaves turn yellow. The bulbs (cloves) may be pickled or used in the same way as onions, but a few should be retained for planting the following year.

Carrots do best on light sandy soil, especially when newly broken. Seed should be sown thinly in drills, 1 inch deep, from April to May, and again in June. The late sowing generally escapes an attack of the carrot fly maggot, and provides nice tender roots for autumn and winter use. Showery weather is the most suitable time for thinning the seedlings, and care should be taken to keep the shoulders well covered with soil. The use of soot, &c., as recommended for onions, will do much to minimise attacks of the carrot fly.

Carrots may be stored in sand or ashes, in a cold cellar or shed. In some favourable districts, however, they may be left in the ground practically all the winter—especially those sown late—and lifted as required.

Varieties:—Long Red Surrey, James' Intermediate, Early Nantes, Early Gem, &c.

Parsnips, as regards soil and general culture, may receive much the same treatment as carrots.

Seed may be sown in February, March, or April, 1 inch deep, in rows 15 inches apart, and the seedlings thinned to 9 inches apart.

Parsnips, on account of their hardiness, may be left in the soil all the winter, and lifted as required for use.

Varieties:—Sutton's Tender and True, Hollow Crown.

Beetroot is a tender plant, and should not be sown quite so early as the carrot; April or May will be early enough. The general culture is the same as for carrots. A slight dressing of common salt or rotted seaweed is beneficial. The round turnip-rooted kinds are early, and do well on soils that are not adapted to deep-rooted varieties.

The roots must be lifted carefully in the autumn, to prevent them being damaged, as this would cause a loss of colour

through "bleeding." They may be stored in a frost-proof shed or cellar, being placed in layers and covered with sand to keep them fresh.

Varieties:—Sutton's Globe, Dobbie's Blood Red, Dell's Crimson.

When difficulty exists in growing good carrots, parsnips, or beetroot, holes may be bored in the ground 2 to 3 feet deep, and 3 to 4 inches in diameter, and filled with a prepared compost. This compost should consist of two parts sifted sandy loam or old potting soil, two parts sifted leaf mould, and one part burnt vegetable refuse or wood ashes, with the addition of 1 lb. of bone meal to every bushel of the compost. Three or four seeds are then placed in each filled-up hole and finally thinned, leaving one plant in each.

Leeks are very hardy, and form a most useful garden vegetable. Large leeks are obtained by sowing the seed under glass, as recommended for onions, planting outdoors in well-manured trenches, and gradually earthing up to cause blanching, and larger growths. Paper collars for blanching purposes are used by some growers.

Good useful crops may be had by sowing the seed outdoors in April, transplanting in June or July, 6 to 12 inches apart in trenches on well-manured ground, and earthing up as required.

Varieties:—The Musselburgh, The Lyon, Dobbie's Exhibition.

Celery plants are generally raised under glass, hardened off, planted out 9 inches apart in well-manured trenches, and earthed up when 8 to 10 inches high, care being taken to prevent any soil falling into the centres of the plants. For this purpose strong brown paper, 15 inches by 8 inches, may be wrapped round each plant before earthing up, but for ordinary requirements this is not essential.

This crop requires plenty of manure, and ample supplies of water to the roots.

Celery may be lifted as required for use, and during very severe weather the plants can be protected with mats, straw, or bracken.

Spinach.—The round or summer kinds, and prickly or winter kinds, are useful vegetables, and may be grown as inter-crops or catch crops. Good, deep, cool soil, to produce large leaves and prevent premature seeding, and careful thinning, are essential points in their cultivation.

Rhubarb will grow practically anywhere, and with little attention, but it is advisable to give plenty of manure in the winter or early spring. A fair proportion of leaves should be left to strengthen the plants for another year.

Plants not doing well should be lifted and divided, the best pieces only being again put in on well-manured and deeply cultivated soil.

Varieties:—Victoria, The Sutton, Dawe's Champion.

STORAGE OF ROOT CROPS FOR WINTER USE.

It is important to preserve from frost such root crops as carrots, beetroot, and turnips. These may be lifted in October or November, before the advent of hard frost, trimmed, and stored with alternate layers of sand or dry soil in a cool frost-proof cellar or shed. In some districts turnips and swedes may be left in the ground and lifted as required for use. The latter method is the best to adopt for Jerusalem artichokes and parsnips, which are quite hardy and are improved by being left in the ground.

Onions, after being lifted and allowed to dry on the ground for a few days, should be "bunched" and hung up in a shed or any place where they will be kept dry. Light or frost does not harm them, but moist conditions must be avoided.

Potatoes should be stored either in cellars or light-proof and frost-proof sheds. Where small quantities are concerned this is preferable to the making of "pits" or "clamps."

Potato tubers for planting may be selected at the time of lifting the crop, choosing medium-sized tubers. These should be exposed to light and air, to harden and green them, and to produce short, sturdy sprouts, but the tubers must be protected from frost. It is desirable to sprout carefully a few good early kinds and plant them on sheltered borders or in frames for early use.

stage that insects do most damage to plants. *Pupa or Chrysalis*—The larvae either bury themselves in the ground or spin a silky cocoon, changing into the pupal stage, from which the imago, or perfect insect, is destined to eventually emerge.

Remedies and Preventives.—Many remedies have been suggested from time to time, but prevention is the best of all remedies. Insects are always lurking about, so a sharp look-out should be kept for their first appearance, in order that they may be attacked immediately.

Good cultivation, suitable manuring, keeping down weeds, burning all infested plants, dead leaves, and rubbish in the garden and orchard; keeping plant houses clean, well ventilated, and carefully watered, are some of the preventive measures which should be adopted.

Spraying mixtures may be made of either of the following:—

(1) A solution of soapsuds.

(2) 2 oz. carbolic soap dissolved in 1 gallon of water.

(3) Soft soap, 2 oz., and washing soda, ½ oz., to 2 gallons of water.

Paraffin and soft soap emulsion is used for general spraying purposes, and may be prepared as follows:—Solar distillate paraffin, 4 pints; soap, 1½ lb.; water, 10 gallons. Dissolve the soap in boiling water, and while still very hot add the paraffin, afterwards churning with a force-pump or syringe until the whole is a creamy mass. Then add sufficient water to bring the whole up to 10 gallons. Double the quantity of oil may be used for winter spraying.

Quasia wash is made by boiling 1 lb. of fresh quasia chips in water for two hours, then straining the extract, and mixing with ½ lb. soft soap, afterwards adding 10 gallons of water. Quasia extract may be obtained from seedsmen.

Soot may be applied with advantage in the case of leaf and root pests. It should be dusted over the plants at frequent intervals, being most efficacious when the foliage is damp.

Salt, applied at the rate of 4 oz. per square yard, or 10 to 12 cwt. per acre, or gas lime, 1 lb, per square yard, are both

useful for such soil pests as wireworm, leather jacket, chafer grubs, &c. They should be applied when the land is free from a crop.

Wood Ashes is beneficial in some cases for soil pests, being, in addition, of some manurial value to crops.

Lime, when used freshly slaked, destroys certain soil pests, and can also be used as a preventive against attacks of the celery, onion, carrot, and beet flies.

PESTS OF VEGETABLE CROPS.

Cabbage-root maggot or cabbage fly.—The maggots attack the roots and stems of the cabbage, cauliflower, and turnip.

Preventives and remedies:—(1) Less animal manure and more artificial manures such as kainit, superphosphate, and nitrate of soda should be used.

(2) Lime may be applied.

(3) Destroy all badly infested plants.

(4) Practice rotation of cropping and trench deeply to bury the larvae.

(5) Before transplanting, the roots of the plants may be dipped in a mixture of clay, soot, paraffin, and water.

(6) A teaspoonful of nitrate of soda placed round the collar of the plants after transplanting has proved efficacious in some cases.

(7) Soot or gas lime spread round the plants has also proved effective.

Cabbage and turnip gall weevils.—The weevils attack the seedlings, causing small round or marble-like swellings on the roots. One or more small maggots will be found inside each swelling, or, if empty, the small hole will be observed through which the fully fed larvae have emerged. The swellings or galls should be cut away before planting and burnt. The old cabbage stalks should also be burnt, and the crop changed the following season, when the ground should be double dug in order to bury the larvae as deeply as possible. This

SALADS.

Medical men of high reputation admit that the appetite for fresh, crisp, uncooked vegetables is a really healthy craving, and that free indulgence in salads is a means of supplying the human frame with important elements of plant life. The salts or minerals contained in them are valuable in rendering solid constituents of food soluble for digestion. They supply phosphorous and lime to the bones, soda to the blood, silica to the teeth and nails, &c.

Lettuce.—Both cos and cabbage varieties are generally sown on seed beds and transplanted to any vacant ground, 9 to 12 inches apart. Early supplies are obtained by sowing under glass in February or March, gradually hardening off, and planting out on a sheltered border. Three or four sowings may be necessary to keep up a supply.

Lettuce require fairly rich, cool, moist soil to encourage quick growth, giving succulent and tender plants.

Radishes, of which there are several kinds—long, short, red, pink, white, olive, and black—require to be sown on rich, cool, moist soil, to encourage rapid growth, which results in tender, juicy roots. Radishes, like other salad plants, require to be grown quickly, or they may be tough and bitter. They should be used in a fresh, young state.

Mustard and Cress are two popular annuals easily grown. A little warmth and shade encourages quick growth. They are cut when about 2 inches high, and frequent sowings will be necessary to keep a supply. Winter and spring crops must be sown under glass.

HERBS.

Herbs for flavouring or making sauces are of considerable interest and importance in nearly all households.

There are several kinds. The tender annuals, such as sweet basil, may be sown under glass and planted out when danger of frost is over.

Hardy annual or biennial kinds, such as parsley, borage, caraway, chervil, marigold, summer savory, coriander, dill,

&c., may be sown in small circular patches or in drills about 1 foot apart, kept free from weeds, and thinned if required.

Perennial herbs, such as sage, mint, thyme, balm, chives, marjoram, winter savory, hyssop, tarragon, fennel, horehound, mugwort, wormwood, lavender, rosemary, rue, sweet cicely, costmary, &c., might be planted in a special bed. Many of them are easily propagated by cuttings or by division of the root-stock. Some will not succeed in all districts, *e.g.*, rue, rosemary, lavender, pot marjoram, &c., in which case a plant of each might be kept in a frame during winter.

Herbs for flavouring and sauces may be used in a fresh state when obtainable, but for winter use some of the shoots may be cut in summer when in a good condition, hung up to dry, and placed in paper bags. Parsley, sage, mint, &c., may be quickly dried in a warm oven or on the rack of the kitchen range. When dry, the leaves may be rubbed down to a powder, placed in jars or tins, and kept for future use.

INSECT AND OTHER ANIMAL PESTS OF GARDENS.

Preliminary Observations.—Nearly all plants, when grown in large quantities, and under conditions of a more or less artificial nature, are liable to be attacked by some kind of pest —animal or vegetable. Generally, however, these pests can be prevented, or held in check, by one or other of the many methods now known to cultivators.

The life history of the various garden pests is a subject worthy of more careful study, as the cultivator would then be in a better position to attack them in their most vulnerable stage.

The life history of a typical insect may be summarised as follows :—

Imago, or the fully-formed insect (moth, fly, or beetle), lays *Eggs*, which vary very much in size, shape, or colour, according to the kind of insect. These eggs, when hatched, become *Larvae*, which are termed caterpillars in the case of butterflies, moths, and sawflies; maggots in the case of flies; and grubs in the case of beetles. It is during the larval

in the grub stage for three or four years, causing much damage to all kinds of crops during this period of its existence.

There is no royal road to success in dealing with this pest, but many of the following remedies may prove effectual:—

(1) Good clean cultivation of the soil, to destroy suitable places for egg laying.

(2) Constant working of the soil will kill many of the pests as they change from one stage to another.

(3) Good drainage is desirable.

(4) Liming the soil, together with the use of nitrate of soda or kainit, will stimulate growth, thus giving the crops a good start, and at the same time cause some harm to the pests.

(5) Soot worked into the soil is attended with beneficial results.

(6) Disulphide of carbon may be used, or some fumigant such as "Vossolite," "Killogrub," "Vaporite," &c., worked into the soil.

(7) Birds and poultry will eat the larvae on freshly turned soil.

(8) Hand-picking can be resorted to in the case of soil used in greenhouses, or when digging the soil in the garden.

(9) Traps, consisting of pieces of carrot, potato, apple, rape cake, &c., may be inserted in the soil, examined at intervals, and all grubs destroyed.

(10) The grubs show a great liking for rape dust and mustard plants, and the former placed between the crops, and the latter sown as an inter-crop, will attract wireworms, leather jackets, and chafer-grubs from the main crop under cultivation.

Leather jacket (Tipula sp.).—The leather jacket is the larva of the crane fly or daddy longlegs.

The larvae do immense damage to the roots of crops, especially on newly-broken land. The eggs may be introduced

into gardens by means of half-decayed leaves, road sweepings, manure, &c., from a badly-formed compost heap.

Hand-picking the grubs has proved effective in many cases, a pointed stick being used to remove the soil from around attacked plants. The remedies suggested under wire-worms are also applicable to this pest.

Chafer-grubs.—One of the commonest is the larva of the May bug (*Melolontha vulgaris*). The beetles are light brown in colour, and are very plentiful on summer evenings, especially in some seasons and districts, when they occur in great numbers.

Hand-picking, good, deep, and constant cultivation, and the use of stimulating manures to encourage quick growth, will do much to keep down this pest. Plants not thriving should be carefully examined at the roots to ascertain whether or not the cause is due to the presence of these larvae.

Green fly or aphides (Aphis sp.).—Several kinds are known, each attacking some particular species of plant, but some species pass the winter on another plant. Thus the hop aphis winters on the plum and damson. A study of the life history will indicate the best time to destroy each kind, so as to prevent their rapid propagation, and to prevent the development of the *winged* female brood. They may be kept in check by early and persistent spraying with paraffin emulsion, tobacco extract, quassia extract, &c., or one of the many preparations on the market. The latter, being ready for immediate use, will be found convenient for the amateur or small grower.

Earwigs.—The flower buds of dahlias and other plants are often greatly damaged by earwigs. These insects are active at night, but hide themselves during the day. They may be trapped by means of pots, containing dirty paper or moss, inverted on sticks placed among the plants. The pots should be frequently examined, and the pests destroyed. Earwigs are often found in hollow stems, straw, &c., and may be trapped in this manner also.

pest does least damage to cabbages which have been transplanted. The weevils deposit their eggs on seedlings in the seed bed, and it is possible that, if some soil fumigant, or lime, basic slag, wood ashes, or soot, was incorporated with the soil before sowing the seeds, this would have the effect of keeping away the weevils. Covering the seed beds with fine muslin or cheese cloth might also prevent egg laying.

Cabbage moth and white cabbage butterfly.—The caterpillars feed on the leaves of cabbages and allied plants, and may be destroyed by (*a*) hand-picking; (*b*) dusting the plants with lime, soot, or gas lime powder; or (*c*) spraying with brine or lime water. General cleanliness in the garden, rotation of crops, and deep cultivation will all have a tendency to hold these pests in check.

Onion fly.—The maggots are hatched from eggs deposited by the fly at the bases of the leaves of the seedlings.

Plants raised under glass and transplanted are less liable to be attacked than those sown in the open. The planting of small onion sets (small dry bulbs, about the size of marbles), gives good results in many gardens, and should be tried in districts where onion cultivation is generally a failure. Many are the remedies suggested for this troublesome pest, and the following are among the most suitable:—

(1) The onion bed should receive a good dressing of lime, soot, wood ashes, or gas lime, and be deeply dug in order to bury the chrysalis.

(2) Before sowing the seed treat the seed drills with spirits of tar, 1 gallon to 2 bushels of peat or sand. This is sufficient for a row 60 yards long.

Paraffin or sheep dip mixed with sand or peat may be used in a similar manner.

(3) The seedlings, or newly transplanted plants, should be dusted at frequent intervals with soot or lime; or "Vaporite," "Vossolite," &c., might also be useful for this pest.

(4) All infested plants should be carefully lifted by means of a handfork, keeping the soil attached, and the whole burnt.

Carrot fly.—The foregoing remarks concerning the onion fly are applicable here, with the exception that carrots are not usually transplanted.

Avoid thinning the plants in very dry weather, and give a good watering immediately the operation is completed. Drawing soil over the crowns of the seedlings is an additional preventive measure. Grass clippings from the lawn sprinkled lightly over the seedlings of carrots, turnips, &c., also help to keep away troublesome pests.

Celery and parsnip fly.—The larva of this insect is a leaf miner, being found between the upper and lower skins of the leaf, where it feeds on the tissues, producing large, unsightly blotches.

Spraying with quassia extract or paraffin emulsion, or dusting the plants with soot or lime after planting, deters the fly from egg laying.

All infected portions of the leaves should be picked off and burnt, and this may prevent a severe attack of the pest in the autumn.

As this insect sometimes attacks the leaves of bishop-weed and other plants belonging to the same family, care should be exercised in keeping the land free from such weeds.

Turnip flea beetle.—This insect—the so-called "Turnip Fly"—causes immense damage to the turnip crop (and other closely related plants) in the early stages of its growth, by feeding on the young fleshy seed leaves (cotyledons). The presence of these small beetles is especially noticeable during hot, dry, or very cold dry weather, when growth is slow. It is therefore important to sow on a well-prepared seed bed, during weather suitable for rapid growth. Superphosphate, or some other artificial manure, drilled in with the seed—which should be new—will encourage quick growth.

Soot, lime, or dry road sweepings dusted over the plants will tend to keep the pest in check.

All cruciferous weeds should be destroyed.

Wireworms (Agriotes sp.).—The wireworm is the larval stage of the click beetle, or skip jack. Unlike most insects, it remains

Slugs and snails.—Both slugs and snails are very troublesome in damp or shady gardens, doing a considerable amount of damage to choice plants.

The following are among the many remedies which may be tried :—

(1) Cleanliness in the garden, destroying all rubbish, &c., which might afford shelter.

(2) Deep autumn cultivation of the soil.

(3) Hand-picking at night, especially after rain.

(4) Trapping by means of cabbage or rhubarb leaves, or with boards laid near their haunts. These should be examined daily, in order that the pests may be destroyed.

(5) Sharp sand, soot, salt, wood ashes, charcoal dust, or granite chips placed round the plants, or lime put down two or three nights in succession, has proved effectual. One dusting of lime is not sufficient to kill slugs, but two or three applications will destroy them before they have had time to renew their coats.

(6) Strong lime or salt water may be effective under certain conditions.

(7) Collars of zinc placed round valuable plants will afford protection, as snails will not crawl over zinc.

(8) Ducks and birds are fond of these creatures, and will devour large numbers of them. Slow-worms and frogs will also eat slugs readily.

(9) Several preparations on the market, *e.g.*, "Slugene," "Slug-death," "Slugicide," "Naptho-Nicotyl," "Vaporite," "Apterite," "Sanitas Powder," &c., are useful in killing slugs and snails.

PLANT DISEASES CAUSED BY FUNGI.

Preliminary Observations.—Plants, like animals, are often attacked by some fungoid disease, and in this respect cultivated plants are more susceptible than wild plants. There are many

kinds of diseases known, but only a few of the more common will be noted here.

Diseases proper are due to the attack of fungi which belong to a low type of plant life, and are mostly microscopic in structure.

Some fungi—termed saprophytic fungi—live on dead or decaying matter, and are quite harmless to living plants. Examples of this class are found in mushrooms, toadstools, &c.

On the other hand, those fungi which attack and live upon living plants, *e.g.*, rusts, smuts, mildews, moulds, &c., are known as parasitic fungi, as they are harmful to the higher types of plants.

Fungicides, *i.e.*, fungus killers or remedies against attacks of plant diseases.

Bordeaux Mixture.—Copper sulphate, 2 lb.; quicklime (fresh burnt), 2 lb.; water, 20 gallons.

Method of mixing:—Dissolve the copper sulphate in a tub (metal vessels must *not* be used) in a small quantity of water. Mix the lime also with a small quantity of water—in a separate vessel—until a milky liquid is formed. Then add the two solutions together, and afterwards make up with water to 20 gallons. When using keep the lime in suspension by stirring occasionally.

Note.—The copper sulphate should be pure (98 per cent. purity). It is also known as blue vitriol, blue copperas, and bluestone, and is sold at about 3d. per lb., or 28s. per cwt.

Bordeaux Mixture is now obtainable in powder or paste form from various dealers.

Burgundy Mixture.—Copper sulphate, 2 lb.; washing soda (pure), 2½ lb.; water, 10 gallons.

This is prepared in a similar manner to Bordeaux Mixture, and is generally used for the same purposes.

Diseases of Vegetable Crops.—*Club root, or finger-and-toe.*—This fungus, which attacks turnips, cabbages, &c., is

capable of existing in the soil for several years without the presence of a host plant. The writer has found that practically all members of the cabbage family (*Cruciferae*) may be attacked by this disease if grown on infected soil. Turnip, cabbage, kale, cauliflower, radish, mustard, cress, wallflower, honesty, candytuft, &c., and such weeds as shepherd's purse, charlock, and wild radish (runch) are all attacked, hence the importance of keeping infected land clear of such crops and weeds whilst attempting to destroy the fungus by liming (gas lime or burnt lime), or some other method of soil sterilisation.

Remedies and preventives:—(*a*) Quicklime applied in autumn at the rate of 28 lb. to 56 lb. per pole, after the crop affected has been removed.

(*b*) A complete change of crop when planting the infected piece of land again.

(*c*) Avoid the use of manures such as superphosphate and sulphate of ammonia.

(*d*) Basic slag and potash give good results.

(*e*) When planting, dip the roots of cabbage or cauliflower plants in a puddle made by mixing clay or soil with soot and sulphur.

Potato disease (Phytophthora infestans).—The well-known potato blight may be kept in check by spraying with Bordeaux Mixture.

Potato wart disease, or black scab.—No cure has yet been discovered for this disease, which seems to be spreading. It is noteworthy that this disease is most prevalent in cottage and allotment gardens, due, probably, to continuous cropping of potatoes on the same piece of land, neglecting to destroy any diseased tubers, and receiving "seed" in exchange which may have been grown on infected land.

Preventive measures which may be adopted.—(*a*) good clean cultivation.

(*b*) Burn diseased crop, or boil before feeding to pigs.

(*c*) Liming the soil.

(*d*) Change the potato crop for some other as recommended under club root.

(*e*) Grow those varieties of potatoes least liable to attack, *e.g.*, Aberlady Early, Abundance, Conquest, Crofter, Golden Wonder, Langworthy, Peacemaker, Provost, Sutton's Discovery, Great Scot, &c.

MEDICINAL PLANTS.

For many years wholesale druggists and chemists have been dependent on the Continent for their supplies of drugs, especially on Germany, Austria-Hungary, and the Balkans, where medicinal plants are extensively cultivated.

These supplies are now cut off, and drugs of all kinds are scarce and expensive. It might pay some of our small-holders and cottagers with large gardens to take up, as a side line, the cultivation of some of the hardier kinds likely to succeed in this country, and thus help to capture some of the trade formerly in the hands of Continental growers.

Quite a number of women interested in gardening are taking this matter up, and a "Women's Herb-growing Association" has been formed to encourage the cultivation of medicinal herbs, pot herbs, and also other plants used in confectionery and perfumery.

Anyone desirous of cultivating herbs, &c., for commercial purposes should plant a good quantity of the sort decided upon, as a mere handful is of little use. The crop, when grown and harvested, should be offered to wholesale druggists. The Board of Agriculture and Fisheries, London, has issued a Leaflet (No. 288) on "The Cultivation and Collection of Medicinal Plants." Copies of this Leaflet may be obtained free on application to the Secretary, Board of Agriculture for Scotland, 29 St. Andrew Square, Edinburgh.

The following are a few of the plants suitable for cultivation in this country: a more complete list of pot herbs, sweet herbs, and medicinal plants will be found in the author's "School

Gardening and Guide to Horticulture," University Tutorial Press, 2s. 6d. :—

Aconite or Monkshood (p).	Marigold (a).
Aniseed (a).	Marjoram (p).
Balm (p).	Opium poppy (a).
Belladonna (p).	Orris Root (p).
Caraway (b).	Peppermint (p).
Comfrey (p).	Rue (p).
Coriander (a).	Sage (p).
Dill (a).	Solomon's Seal (p).
Figwort (p).	Southernwood (p).
Foxglove (b).	Tansy (p).
Hemlock (b).	Tarragon (p).
Henbane (a).	Thornapple (a).
Hyssop (p).	Turkey Rhubarb (p).
Lavender (p).	Wormwood (p).

(*a*) = Annual. (*b*) = Biennial. (*p*) = Perennial.

Bulletin 73.

West of Scotland Agricultural College.

REPORT

ON

WOOD AND PLANT ASHES

AS A

SOURCE OF POTASH.

BY

R. A. BERRY, F.I.C.,

Professor of Agricultural Chemistry.

GLASGOW, 1916.

Wood and Plant Ashes as a Source of Potash.

By PROFESSOR BERRY.

This short report deals with the results of some ash analyses which were made in the autumn of 1914. The object in undertaking the analyses was to determine the percentage of potash in the ash of certain forest and plant produce, and also in flue dust from blast furnaces, with a view to their utilisation as a possible source of potash.

Wood ashes at one time formed the main source of supply of potash salts, but with the discovery of the potash deposits in Germany, a cheaper and practically unlimited supply became available. In consequence, the use of wood ashes as a source of potash for manurial purposes declined, though ashes, owing to the limited quantities available, had never been used to any extent as a manure. At the outbreak of war the value of wood ashes was mainly due to the potassium carbonate which they could supply for the soft soap, glass-making, and other industries.

The more general use of potash manures in agriculture is of comparatively recent date compared with that of nitrogenous and phosphatic manures, and dates practically from the discovery of the German deposits. It was not, however, until about the year 1890 that any quantity of potash manures was used in this country. Since then the annual consumption has steadily gone up until it now reaches large figures.

Potash now finds a place in the manure bill of most farmers, and for the successful cultivation of some crops, especially potatoes, adequate supplies of this manure are essential. So with the cutting off, at the outbreak of war, of the main outside and principal source of supply, it became necessary to exploit any and every likely source of potash available in this country, and at the same time to conserve and utilise to the best advantage the stocks already held. It was, however, hardly to be expected that by encouraging in every way

possible the production and collection of ashes of all kinds, the total quantity of potash produced from this source would have much appreciable effect in meeting the country's demands, yet so long as the present conditions prevail it is necessary to utilise every source of potash available.

The ashes, the analyses of which are given in Table I., were obtained by arrangement with the Forestry Department of the College. They may be taken to be fairly representative, and they were produced and collected under the conditions in operation in practice.

Table I. below gives the percentage of potash in the ash, soluble in (1) strong hydrochloric acid and in (2) water :—

TABLE I.

Ash.	Potash (K_2O) Percentage Soluble in—		Percentage of "Total Potash" † Soluble in Water.
	Strong Hydrochloric Acid.	Water.	
Bracken,	20·45	10·61	51·9
Spruce,	11·94	8·23	68·9
Hardwood Forest Fire,	11·79	6·53	55·4
Hardwood Engine Fire,	10·44	6·77	64·8
Mixed Forest Produce,	3·13	1·50	47·9
Hardwood, largely Oak Trimmings,	3·53	2·75	77·9
Flue Dust for Blast Furnaces—			
No. 1 Sample,	3·75	2·13	56·8
No. 2 ,,	3·93	2·64	67·2

† "Total Potash" = Potash soluble in strong hydrochloric acid.

The ashes show great variability in their potash content. Bracken ash turns out to be surprisingly rich in potash, but apparently very variable in composition, since some recently published results* have shown samples to contain only between 2 and 3 per cent. of potash. At the same time the writer is acquainted with some analyses of other samples of bracken

* See Journal, Bd. of Agriculture, Vol. xxi., No. 8.

ash showing a much higher percentage of potash than that given in the above table. Bracken therefore seems to be a plant peculiarly responsive to environment, and thus liable to great variation in composition. What exactly are the main factors causing the variation in the potash content of bracken ash is uncertain, but the point is being looked into. In any case bracken is a weed of the worst type, so that any attempt to eradicate bracken by cutting, drying, and burning the produce for the ash seems worth while trying, when the value of the ash produced, at the present price of potash, will much more than cover the cost of the attempt. Ten acres of fully stocked bracken land are found to produce 1 ton of ash, the quantity being dependant upon the density of the crop.* The value of the bracken ash, calculated upon the total percentage of potash given in Table I., and upon the price per unit of potash based upon pre-war figures, would be about £4 per ton, but calculated upon the current market value of potash the price per ton would be considerably higher.

Among the other ashes those from the forest produce are the richer in potash, but as the analyses show, their potash content varies greatly according to the source of the ash. Besides the variation due to the different kinds of wood, it is well known that the younger branches, twigs, shoots, &c., yield an ash richer in potash than older wood. The latter, where wood is the fuel, is what is used for engine and mill fires. The quantity of ash produced, or likely to be produced, however, from these sources, is the important economic factor. According to an estimate made,† it is reckoned that in the process of clearing woodland, plantations, &c., the "lop and top" undergrowth, weed growth, and litter in any average type of woodland would, when burnt, produce about half a ton of ash per acre, whilst portable sawmills and timber mills where wood is used as fuel, would, in each case, produce about a quarter of a hundredweight of ash daily.

The flue dust from blast furnaces is poor in potash, containing under 4 per cent. of total potash. The flue dust is derived mostly from coal, and one furnace is said to produce between 40 and 50 tons per annum.

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* See Leaflet No. 25, Bd. of Agric. for Scotland. † *Ibid.*

Other sources of potash, such as the ash from hedge clippings and trimmings, sugar-beet waste, &c., are given in Table IV., which gives the results of a number of analyses made in the College, and also of some analyses taken from other sources.

Considered from the point of view of the total potash content, it is clear from the analyses in Table I. that three of the ashes could quite well be used as potash manures in place of low grade potash salts, such as kainit, which contains 12·4 per cent. of potash. One ton of bracken ash, for example, might in some cases quite easily contain more than twice the amount of potash contained in 1 ton of kainit. But it must be remembered that the potash in kainit and the ordinary potash manures is entirely soluble in water, whereas only between 50 and 70 per cent. of the total potash in the ashes is soluble in water. Therefore, to make up for the deficiency in solubility, the ashes must be used in larger dressings.

Besides potash some of the ashes contain relatively large amounts of phosphates, as will be seen from Table II., which gives the percentage of phosphates and some other constituents :—

Table II.

Ash.	Phosphoric Acid expressed as—		Lime, CaO.	Magnesia, MgO.	Manganese Oxide, MnO.
	P_2O_5.	$Ca_3(PO_4)_2$			
Bracken, - - -	3·37	7·35	10·90	3·69	0·84
Spruce, - - - -	7·01	15·30	28·20	2·90	1·35
Hardwood Forest Fire, -	5·23	11·41	25·20	3·80	2·14
Hardwood Engine Fire,	5·02	10·95	44·70	4·71	2·23
Mixed Forest Produce, -	1·54	3·36	12·40	2·03	0·47
Flue Dust from Blast Furnace—					
No. 1 Sample, -	Trace	...	Not determined		
No. 2 ,, -	1·72	3·75			

The phosphates present are practically insoluble in water, and are mostly in the form of calcium and magnesium phosphates. Their value for manurial purposes should be much the same as the value of the phosphates in steamed bone flour, and their presence in such relatively large amounts adds, of course, considerably to the value of the ash both from a manurial and a monetary point of view. The low value of the mixed ash is, in all probability, due to the large admixture of earth which it contains.

With the exception of the lime, the other constituents given in the table are perhaps of interest only, but as the total lime varies from about 11 to over 40 per cent., it must be taken into account.

The ashes when properly burnt are bulky, generally greyish in colour, and of a light, friable, and powdery nature. Sometimes they contain stones and much unburnt material, and should be passed through a sieve with a 3-16th inch mesh. Also owing to possible admixture with earth it is advisable to have the ashes analysed. In the making of the ash care should be taken to keep down the temperature of the fire, which is best accomplished by not keeping too large a fire going. Otherwise, especially if an appreciable quantity of alkaline salts are present, such as in bracken ash, there is a tendency for the ash to fuse into hard vitreous lumps, a condition which is very undesirable.

On no account should the ashes be exposed to rain, otherwise the soluble potash salts (see Table I.) might all be dissolved out and lost. It follows that the ashes must be stored in a dry place.

The ashes are strongly alkaline, and when mixed with ammonium sulphate or any other ammonium salt, they liberate ammonia freely, especially if the ashes are in any way damp. Otherwise, with the exception of ammonium salts, ashes form an excellent medium for mixing with most manures in the making of compound manures, composts, &c.; but, for the reason already stated, on no account should they be mixed with ammonium salts.

The ashes can be used alone, but owing to their caustic nature they are best applied before the seed is sown.

As the value of the ashes is judged by the amount of potash and phosphates which they contain, the following Table III. may be useful for the purpose of comparison :—

TABLE III.

ASH.	Total Potash, K_2O.	Percentage of "Total Potash" Soluble in Water.	Phosphate of Lime, $Ca_3(PO_4)_2$.	Total Lime, CaO.
Bracken, - - -	20·45	51·9	7·35	10·90
Spruce, - - - -	11·94	68·9	15·30	28·20
Hardwood Forest Fire, -	11·79	55·4	11·41	25·20
Hardwood Engine Fire,	10·44	64·8	10·95	44·70
Mixed Forest Produce, -	3·13	47·9	3·36	12·40
Hardwood, largely Oak Trimmings, - -	3·53	77·9	2·40	Not determined
Flue Dust from Blast Furnaces—				
No. 1 Sample, -	3·75	56·8	Trace	
No. 2 ,, -	3·93	67·2	3·75	

Table IV. gives the analyses of a number of miscellaneous substances containing potash :—

TABLE IV.

SUBSTANCE.	Percentage Total Potash, K_2O.
Ash from Sugar-Beet Waste,	46·48
Crude Potash from Iron Works,	44·6
Kelp,	18·77
Flue Dust from Sawmills,	2·27
Ashes from Hedge Clippings and Cleanings,	10·9
Kiln Scrapings,	1·55
Sewage Sludge,	2·60
Eifellith,	6·05
Liquid Manure,	0·462
Farmyard Manure,	0·381
Ash of Tobacco Stalks,	55·4
Ash of Tobacco Leaves,	20·5
Ash of Cotton Seed Hulls,	22·47
Potash Feldspar,	17·0
Suint Ash,	60·2

My thanks are due to Mr. Peter Caldwell, who made the ash analyses contained in this report.

ULLETIN No. 74.

The West of Scotland Agricultural College.

REPORT

ON

THE WEATHER

AT KILMARNOCK

FOR THE THREE YEARS 1913, 1914, and 1915,

BY

REGINALD A. BERRY, F.I.C.,

Professor of Agricultural Chemistry.

GLASGOW, 1916.

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REPORT ON THE WEATHER

FOR THE THREE YEARS

1913, 1914, and 1915.

By Professor BERRY.

The data for this report are taken from the observations made at the College Meteorological Station at Kilmarnock. The station is situated in the experiment field adjacent to the steading on the Holmes Farm, and stands at a height of about 80 feet above sea-level. The equipment of the station remains as in former years, and includes the following instruments :—

Standard Maximum Thermometer.
Standard Minimum Thermometer.
Wet and Dry Bulb Thermometer.
8-inch Rain Gauge.
Campbell Stokes Sunshine Recorder.
Standard Fortin Barometer.

Observations are taken daily at 9 a.m. Detailed summaries are forwarded monthly to the Scottish Meteorological Society, Edinburgh, and to the *Scottish Farmer* office, for publication in their Journals. For the figures relating to the Glasgow weather, given in Tables I., pages 155, 162, and 169, we are indebted to Professor Becker, the City Observatory, Glasgow.

The observations were made by Mr. B. P. Perry up to the month of May, 1915, when he left for active service with His Majesty's forces. The work is being continued by Mr. Peter Caldwell.

1913.

Summaries of the weather for this year are contained in the tables given below, and they include :—

Table I., which compares the monthly and yearly weather records for Glasgow and Kilmarnock.

Table II., which contains the monthly rainfall, the number of rainy days, and their difference from the monthly mean.

Table III., which contains quarterly rainfalls and differences from the mean.

Table IV., which contains the number of hours of bright sunshine, the mean temperature, and their difference from the monthly mean, also the highest, the lowest, and the greatest range of temperature for each month.

Table V., which gives the days on which frost was recorded.

TABLE I.

MONTH.	KILMARNOCK, 1913.					GLASGOW, 1913.			
	Rainfall.	*Rainy Days.	Mean Temperatures.	Sunshine.		Rainfall.	*Rainy Days.	Mean Temperatures.	Sunshine.
	Inches.		F.°	H.	M.	Inches.		F.°	H.
January, -	3·01	18	38·05	24	30	3·45	18	38·4	7
February, -	1·92	16	40·50	39	36	2·92	14	40·6	17
March, -	3·72	22	41·45	97	54	3·94	25	40·9	76
April, - -	2·35	18	44·95	121	18	2·84	18	44·9	103
May, - -	2·81	19	50·40	157	54	3·37	20	49·6	111
June, - -	2·65	17	55·40	151	18	3·00	19	54·9	121
July, - -	1·48	11	56·80	191	36	1·29	8	57·5	185
August, -	1·52	13	56·60	146	36	1·05	10	57·2	121
September, -	2·42	10	53·50	100	18	2·28	10	53·8	54
October, -	1·91	16	50·20	86	30	1·71	19	50·2	76
November, -	4·88	27	45·40	38	42	5·29	22	45·8	31
December, -	4·90	20	40·40	22	0	3·41	18	40·9	21
Whole Year,	33·57	207	47·8†	1,178	12	34·55	201	47·9†	923
Y'rly Average,	39·32	205	46·9	1,181	29	38·39	211	46·9	1,095

* ·01 inch Rainfall constitutes a rainy day.
† Monthly average.

TABLE II.

MONTH.	RAINFALL (INCHES.)							*RAINY DAYS.	
	1908.	1909.	1910.	1911.	1912.	1913.	Difference of 1913 from Average of 1901-1913.	1913.	Difference of 1913 from Average of 1901-1913.
Jan., -	5·15	4·72	3·25	2·89	2·14	3·01	−0·70	18	−1
Feb., -	2·93	3·22	4·85	6·18	2·19	1·92	−1·20	16	−1
Mar., -	4·06	1·62	1·69	1·41	4·88	3·72	+0·37	22	+3
April, -	1·97	4·05	2·89	2·68	1·98	2·35	−0·21	18	+3
May, -	2·62	2·39	2·11	2·35	1·16	2·81	+0·23	19	+2
June, -	2·62	3·07	1·45	2·09	3·58	2·65	+0·39	17	+4
July, -	2·81	4·76	3·23	2·47	2·29	1·48	−1·44	11	−5
Aug., -	4·00	3·49	7·19	2·53	2·96	1·52	−2·78	13	−6
Sept., -	5·09	2·12	2·07	2·02	2·65	2·42	−0·48	10	−4
Oct., -	0·97	4·69	2·37	2·69	3·64	1·91	−1·87	16	−1
Nov., -	3·52	2·55	3·31	4·08	3·56	4·88	+1·33	27	+9
Dec., -	3·86	4·23	3·54	4·62	5·73	4·90	+0·61	20	−1
Whole Year,	39·60	40·91	37·95	36·01	36·76	33·57	−5·75	207	+2

+ indicates above, and − below the average.
1 inch Rainfall = 100 tons water per acre.
* ·01 inch Rainfall constitutes a rainy day.

TABLE III.

MONTH.	RAINFALL (INCHES).						Difference of 1913 from Average of 1901-1913.	Average quarterly rainfall expressed as percentage of whole year, using average of 1901-1913.
	1908.	1909.	1910.	1911.	1912.	1913.		
Jan.-Mar.,	12·14	9·56	9·79	10·48	9·21	12·14	−1·53	25·9
April-June,	7·21	9·51	6·54	7·12	6·72	7·21	+0·41	18·8
July-Sept.,	11·90	10·37	12·49	7·02	7·90	11·90	−4·70	25·8
Oct.-Dec.,	8·35	11·47	9·22	11·39	12·93	8·35	+0·07	29·5
Whole Year,	39·60	40·91	37·95	36·01	36·76	33·57	−5·75	

TABLE IV.

MONTH.	Hours of Bright Sunshine.				Mean Temperature. F.°		Highest Maximum Temperature F.°, 1913.	Lowest Minimum Temperature F.°, 1913.	Greatest Range of Temperature F.°, 1913.
	1913.		Difference of 1913 from Average of 1902-1913.		1913.	Difference of 1913 from Average of 1902-1913.			
	H.	M.	H.	M.					
January, - -	24	30	− 5	39	38·05	−0·7	52	23	29
February, -	39	36	−14	17	40·50	+1·9	51	26	25
March, - -	97	54	+ 6	36	41·45	+0·4	55	21	34
April, - -	121	18	− 3	39	44·95	+0·9	61	27	34
May, - -	157	54	− 4	58	50·40	+0·5	70	35	35
June, - -	151	18	−18	51	55·40	+0·9	76	42	34
July, - -	191	36	+25	41	56·80	−0·4	77	39	38
August, - -	146	36	+ 9	33	56·60	+0·3	75	38	37
September, -	100	18	− 8	15	58·50	+0·5	70	31	39
October, - -	86	30	+13	59	50·20	+2·2	62	27	35
November, -	38	42	− 2	15	45·40	+3·8	54	29	25
December, -	22	0	− 1	12	40·40	+0·4	55	20	35

+ indicates above, and − below the average.

Table V.

Month.	Occurrence of Frost, 1913.
January, - -	6th, 12th, 13th, 14th, 15th, 22nd, 23rd, 25th, 26th, 27th.
February, -	1st, 6th, 17th, 18th, 19th, 21st, 22nd, 23rd.
March, - -	8th, 15th, 16th, 17th, 18th, 24th.
April, - -	1st, 2nd, 6th, 7th, 8th.
September, -	17th.
October, - -	7th, 24th.
November, -	7th, 8th, 9th, 22nd.
December, -	5th, 6th, 7th, 17th, 18th, 25th, 28th, 29th, 30th, 31st.

REMARKS ON THE WEATHER OF EACH MONTH.

January—The month opened with mild and changeable weather, which continued until the 10th. A slight frost was registered on the 6th. A heavy fall of snow occurred on the 11th, and wintry weather with snow showers prevailed until the 15th, thereafter, until about the 24th, the weather was mild and unsettled. A sharp frost was registered on the 25th, and snow fell on the 31st. The rainfall and bright sunshine was normal. Prevailing winds—south. *February*—The weather for the first half of this month was stormy and unsettled. In some districts considerable damage was done by floods. The latter half of the month, however, was more settled. There was a cold easterly wind, and the weather was dry and frosty, no rain being registered between the 14th and 25th. The land dried well, and good progress was made with the ploughing. The rainfall was 1·2 inches below normal. Prevailing winds—east and south-west. *March*—Stormy weather prevailed until well on in the month, some rain being recorded on 19 out of the first 21 days. Snow showers occurred on the 8th, 14th, and 16th. There was an absence of the cold, dry easterly winds so essential for the proper cultivation of the land and the preparation of a good seed bed.

After the 20th the wind settled in the east, and a spell of the typical March weather was experienced. The rainfall and mean temperature was above the average. Prevailing winds—south-west. *April*—The improved weather conditions of the latter part of last month continued until about the 10th, and good progress was made with the seeding operations and potato planting. Afterwards rainy days were frequent until the end of the month. The rainfall and bright sunshine was a little below the average. Prevailing winds—south. *May*—The rainfall for this month was a little above the normal. The weather was cloudy and cold, but no frost was recorded. Vegetation made slow progress; however the cereals brairded well, and the crops had a healthy appearance. Turnips were sown under favourable conditions. Prevailing winds—south and west. *June*—The first half of the month was changeable, some days being bright and sunny, whilst others were very wet. No rain was recorded between the 13th and 19th; afterwards showery weather prevailed until the end of the month. The crops were somewhat backward owing to the cloudy and cool weather conditions; at the same time there was promise of a good hay crop. The rainfall was a little above the average. Prevailing winds—south-west and west. *July*—The bright sunny conditions of this month were very welcome after the dull unseasonable weather of the previous months. There was a deficiency of 1·44 inches of rain below the normal. Haymaking was carried on in ideal weather, and the crop was above the average. Cereal crops made good progress towards the end of the month, and there were prospects of a good and early harvest. Prevailing winds—south-west. *August*—The dry weather of July continued throughout the greater part of this month, only ·17 inch of rain being registered between the 1st and the 19th. This month was one of the driest Augusts on record. The total rainfall was 1·52 inches, which is a deficiency of 2·78 inches from the normal. On the light soils and in the drier districts crops suffered a good deal from the droughty conditions. Harvesting was general towards the end of the month. Prevailing winds—west and south-west. *September*—No rain was recorded in the first week, and the weather was ideal for harvesting. However, rainy days occurred about the middle of the month. ·67 inch of rain was recorded on the 13th. On the whole the weather was drier

than usual, and the crops were gathered in splendid condition. Ploughing of the stubble became general in many districts towards the end of the month. Prevailing winds—east. *October*—The weather for this month was remarkably fine and mild, the rainfall being 1·87 inches below the normal and the mean temperature 2·2 degrees above the average. Only two frosts were recorded. Prevailing winds—south. *November*—This month was unusually open and mild, the mean temperature being 3·8 degrees above the normal. Only four frosts were recorded. The days were dull and wet, rain being recorded on 27 days. The rainfall was 1·33 inches above normal. Prevailing winds—west. *December*—The weather for this month was very changeable, short spells of wet and frosty weather alternating throughout the month. The rainfall was ·61 inch below normal. Prevailing winds—west.

The outstanding features of the year were:—A deficiency of 5·75 inches of rain and a backward spring, followed by an unusually long spell of dry weather all through the summer; a good hay and corn harvest, and an exceptionally mild autumn.

1914.

Summaries of the weather for this year are contained in the tables given below, and they include :—

Table I., which compares the monthly and yearly weather records for Glasgow and Kilmarnock.

Table II., which contains the monthly rainfall, the number of rainy days, and their differences from the monthly mean.

Table III., which contains quarterly rainfalls and differences from the mean.

Table IV., which contains the number of hours of bright sunshine, the mean temperature, and their differences from the monthly mean, also the highest, the lowest, and the greatest range of temperature for each month.

Table V., which gives the days on which frost was recorded.

TABLE I.

MONTH.	KILMARNOCK, 1914.					GLASGOW, 1914.				
	Rainfall.	*Rainy Days.	Mean Temperatures.	Sunshine.		Rainfall.	*Rainy Days.	Mean Temperatures.	Sunshine.	
	Inches.		F.°	H.	M.	Inches.		F.°	H.	
January, -	3·91	17	37·7	11	0	3·09	17	39·5	8	
February, -	4·43	25	42·5	26	0	3·21	25	43·5	25	
March, -	4·41	24	40·6	97	6	4·58	22	40·8	75	
April, - -	2·62	14	48·2	175	42	2·29	15	48·0	157	
May, - -	1·83	18	48·9	140	30	1·68	17	49·4	101	
June, - -	0·76	14	56·1	189	6	0·54	11	56·5	167	
July, - -	2·32	10	58·7	158	24	2·80	15	58·2	108	
August, -	4·33	16	58·7	171	12	4·21	18	58·2	148	
September, -	1·90	13	54·0	156	6	1·98	13	53·8	113	
October, -	2·37	13	49·05	72	48	1·27	16	49·6	49	
November, -	5·04	21	42·8	52	42	4·58	22	43·6	31	
December, -	4·11	19	38·1	25	36	6·02	23	38·7	13	
Whole Year,	38·03	204	47·94†	1,276	12	36·25	214	48·3†	995	
Y'rly Average,	39·23	205	46·98	1,188	46	38·34	211	46·5	1,092·0	

* ·01 inch Rainfall constitutes a rainy day.
† Monthly average.

TABLE II.

MONTH.	RAINFALL (INCHES).								* RAINY DAYS.	
	1908.	1909.	1910.	1911.	1912.	1913.	1914.	Difference of 1914 from Average of 1901-1914.	1914.	Difference of 1914 from Average of 1901-1914.
Jan., -	5·15	4·72	3·25	2·89	2·14	3·01	3·91	+0·91	17	−1
Feb., -	2·93	3·22	4·85	6·18	2·19	1·92	4·43	+1·22	25	+8
Mar., -	4·06	1·62	1·69	1·41	4·88	3·72	4·41	+0·99	24	+5
April, -	1·97	4·05	2·89	2·68	1·98	2·35	2·62	+0·07	14	−1
May, -	2·62	2·39	2·11	2·35	1·16	2·81	1·83	−0·69	18	+1
June, -	2·62	3·07	1·45	2·09	3·58	2·65	0·76	−1·39	14	+1
July, -	2·81	4·76	3·23	2·47	2·29	1·48	2·32	−0·56	10	−5
Aug., -	4·00	3·49	7·19	2·53	2·96	1·52	4·33	+0·04	16	−2
Sept. -	5·09	2·12	2·07	2·02	2·65	2·42	1·90	-0·92	13	-1
Oct., -	0·97	4·69	2·37	2·69	3·64	1·91	2·37	-1·31	13	−3
Nov., -	3·52	2·55	3·31	4·08	3·56	4·88	5·04	+1·39	21	+3
Dec., -	3·86	4·23	3·54	4·62	5·73	4·90	4·11	−0·17	19	+1
Whole Year,	39·60	40·91	37·95	36·01	36·76	33·57	38·03	−0·42	204	+6

+ indicates above, and − below the average.
1 inch Rainfall = 100 tons of water per acre.
* ·01 inch Rainfall constitutes a rainy day.

TABLE III.

MONTHS.	RAINFALL (INCHES).							Difference of 1914 from average of 1901-1914.	Average quarterly rainfall expressed as percentage of whole year, using average of 1901-1914.
	1908.	1909.	1910.	1911.	1912.	1913.	1914.		
Jan.-Mar.,	12·14	9·56	9·79	10·48	9·21	8·65	12·75	+2·39	26·6
April-June,	7·21	9·51	6·54	7·12	6·72	7·81	5·21	−2·02	18·6
July-Sept.,	11·90	10·37	12·49	7·02	7·90	5·42	8·55	−1·45	25·5
Oct.-Dec.,	8·35	11·47	9·22	11·39	12·93	11·69	11·52	−0·81	29·3
Whole Year,	39·60	40·91	37·95	36·01	36·76	33·57	38·03	−1·89	

TABLE IV.

MONTH.	Hours of Bright Sunshine.				Mean Temperature. F.°		Highest Maximum Temperature F.°, 1914.	Lowest Minimum Temperature F.°, 1914.	Greatest Range of Temperature, F.°, 1914.
	1914.		Difference of 1914 from Average of 1902-1914.		1914.	Difference of 1914 from Average of 1902-1914.			
	H.	M.	H.	M.					
January, - -	11	0	−17	40	37·7	−0·9	53	18	35
February, - -	26	0	−25	44	42·5	+3·6	53	31	22
March, - -	97	6	+ 5	22	40·6	−0·33	56	25	31
April, - -	175	42	+46	52	48·2	+4·00	69	32	37
May, - -	140	30	−20	38	48·9	−0·8	66	30	36
June, - -	189	6	+17	31	56·1	+1·5	77	35	42
July, - -	158	24	− 6	55	58·7	+1·5	78	36	42
August, - -	171	12	+31	31	58·7	+2·2	82	40	42
September, -	156	6	+43	54	54·0	+1·9	75	28	47
October, - -	72	48	+ 0	16	49·05	+0·99	64	29	35
November, -	52	42	+10	51	42·8	+0·9	57	19	38
December, -	25	36	+ 2	14	38·1	−1·8	51	19	31

+ indicates above, and − below the average.

TABLE V.

MONTH.	OCCURRENCE OF FROST, 1914.
January, - -	1st, 5th, 6th, 7th, 12th, 13th, 14th, 15th, 16th, 17th, 19th, 20th, 21st, 22nd, 27th, 28th.
February, -	25th.
March, - -	7th, 9th, 10th, 11th, 20th, 22nd, 27th, 28th.
May, - -	24th.
September, -	20th, 21st.
October, - -	29th.
November, -	14th, 15th, 16th, 17th, 18th, 19th, 21st, 22nd, 23rd, 24th, 25th.
December, -	6th, 16th, 19th, 20th, 21st, 22nd, 23rd, 24th, 25th, 28th.

REMARKS ON THE WEATHER OF EACH MONTH.

January—The weather for the early part of this month was exceptionally mild, with a good deal of rain and an occasional frost. After the 11th a spell of dry frosty weather set in, which lasted until the 22nd. From this date until the end of the month the weather was stormy. Heavy rain occurred on the 8th, 24th, and 29th. On the whole the weather for the month was about normal. Prevailing wind—south. *February*—The unsettled conditions which prevailed in the latter half of January continued practically throughout the whole of this month. Twenty-five rainy days were recorded, and the total rainfall was 1·22 inches above the average. The weather was unusually mild, only one frost being registered, and the mean temperature was 3·6 degrees above the average. Heavy falls of rain occurred on the 17th and 22nd. Prevailing wind—south. *March* opened wet and cold, which condition continued until near the end of the month. Twenty-four rainy days were recorded, and the total rainfall was ·99 inch above the normal. The month was unfavourable for farming operations, only on the lighter soils and in the drier districts was it possible to get the seed in under satisfactory conditions. Prevailing wind—west.

April—Rainy and mild weather prevailed until the 13th of this month. After that a remarkably dry and sunny spell of weather set in which lasted out the month. With the improved weather the sowing of the corn and potato planting were pushed on rapidly under conditions which, especially towards the end of the month, were very favourable. Prevailing wind—south-west. *May*—The weather for this month was variable and disappointing. The rainfall was below normal; the days, however, were as a rule, cloudy and cool. The amount of bright sunshine was much below normal, and fell far short of that of the preceding month. Unusually cold weather set in on the 20th, and 2 degrees frost was registered on the 24th. In consequence, considerable damage was done to the early potatoes, particularly in exposed situations. Vegetation made slow progress this month. Prevailing winds—west and south-west. *June*—This month was exceptionally dry—one of the driest months of June on record. The rainfall was 1·39 inches below the average, and only ·75 inch of rain was registered. The latter part of the month was unusually warm and dry, and the crops, especially turnips, suffered a good deal from the droughty conditions. Hay prospects were not good. Prevailing wind—south-west. *July*—A fall of ·86 inch of rain occurred on the 1st of the month, which, after the previous droughty condition, was beneficial to all crops. The rainfall was a little below, and the mean temperature a little above, the normal. Good haymaking weather prevailed generally, and the hay crop, though not heavy, was stacked in good order. Prevailing winds—south-west and north-east. *August*—The first week was showery, the 8th was very wet, ·82 inch of rain being recorded. After that followed a dry spell lasting until the 20th. Harvest became general about this time, and the crops were in good order. The month on the whole was about normal, though the last few days were wet. Prevailing wind—south-west. *September*—The weather for this month was exceptionally fine and dry. The corn in the late districts ripened satisfactorily, and was harvested in good order. The ploughing up of the stubble made good progress. Slight frosts occurred on the 20th and 21st. The rainfall was ·92 inch below normal. The root crops looked well. Prevailing wind—west. *October*—The fine, dry weather of the previous month prevailed practically

through the whole of this month. The rainfall was 2·37 inches, a deficiency of 1·31 inches from the average. The weather was ideal for potato lifting, and there was an entire absence of frost. Prevailing wind—east. *November*—With the opening of this month the long spell of dry weather which had characterised the late summer gave place to dull, rainy weather, which lasted until the middle of the month. Frost occurred from the 14th to the 26th, followed by stormy weather. On the 29th a fall of 1·18 inches of rain was registered within the 24 hours, and some damage was done by floods. The total rainfall for the month was 1·39 inches above normal. Prevailing winds—south-west and east. *December*—The unsettled weather of the latter part of last month continued well into the third week of December. A short spell of frost occurred from the 19th to the 25th. Snowstorms occurred during the month, but the fall was light. On the whole the weather was very changeable.

The outstanding features of this year were the comparatively wet and open spring, followed by an unusually long period of more or less droughty weather, lasting from the middle of April till the end of October, when each month registered a shortage of rain. The hay and corn crops were below the average, but were gathered in excellent condition.

1915.

Summaries of the weather records for this year are contained in the tables given below, and they include :—

Table I., which contains the monthly and yearly weather records for Glasgow and Kilmarnock.

Table II., which contains the monthly rainfall, the number of rainy days, and their differences from the monthly mean.

Table III., which contains the quarterly rainfalls, and differences from the mean.

Table IV., which contains the number of hours of bright sunshine, the mean temperature, and their differences from the monthly mean; also the highest, the lowest, and the greatest range of temperature for each month.

Table V., which gives the days on which frost was recorded.

TABLE I.

Month.	Kilmarnock, 1915.					Glasgow, 1915.				
	Rainfall.	*Rainy Days.	Mean Temperature.	Sunshine.		Rainfall.	*Rainy Days.	Mean Temperature.	Sunshine.	
	Inches		F.°	H.	M.	Inches.		F.°	H.	
January, -	3·62	20	36·70	35	54	2·27	16	38·4	28	
February, -	4·95	21	38·10	52	6	4·09	22	38·7	39	
March, -	1·80	12	40·00	105	24	1·22	14	41·0	112	
April, - -	2·76	20	45·20	164	30	2·19	21	45·3	140	
May, - -	0·80	5	49·40	223	24	1·77	9	49·3	211	
June, - -	2·01	8	56·90	227	36	2·08	11	56·0	216	
July, - -	4·12	19	56·10	208	48	3·72	23	56·4	164	
August, -	2·87	20	57·15	110	12	1·99	19	58·0	99	
September, -	1·12	10	54·30	158	18	1·34	12	54·0	126	
October, -	2·05	14	46·00	89	18	2·76	13	47·0	46	
November, -	1·69	14	35·00	56	6	1·95	9	36·1	47	
December, -	4·74	27	38·00	19	30	5·10	23	39·0	22	
Whole Year,	32·87	190	46·07†	1,451	6	30·48	192	46·6†	1,250	
Y'rly Average,	38·77	198	46·9	1,207	0	38·18	211	46·5	1,096·5	

* ·01 inch rainfall constitutes a rainy day.
† Monthly average.

TABLE II.

Month.	Rainfall (Inches).								*Rainy Days.	
	1909.	1910.	1911.	1912.	1913.	1914.	1915.	Difference of 1915 from Average of 1901-1915.	1915.	Difference of 1915 from Average of 1901-1915.
Jan., -	4·72	3·25	2·89	2·14	3·01	3·91	3·62	−0·18	20	+1
Feb., -	3·22	4·85	6·18	2·19	1·92	4·43	4·95	+1·62	21	+4
Mar., -	1·62	1·69	1·41	4·88	3·72	4·41	1·80	−1·51	12	−6
April, -	4·05	2·89	2·68	1·98	2 35	2·62	2·76	+0·19	20	+5
May, -	2·39	2·11	2·35	1·16	2·81	1·83	0·80	−1·61	5	−11
June, -	3·07	1·45	2·09	3·58	2·65	0·76	2·01	−0·16	8	−5
July, -	4·76	3·23	2·47	2·29	1·48	2·32	4·12	+1·16	19	+4
Aug., -	3·49	7·19	2·53	2·96	1·52	4·33	2·87	−1·34	20	—
Sept., -	2·12	2·07	2·02	2·65	2·42	1·90	1·12	−1·59	10	−3
Oct., -	4·69	2·37	2·69	3·64	1·91	2·37	2·05	−1·52	14	−2
Nov., -	2·55	3·31	4·08	3·56	4·88	5·04	1·69	−1·83	14	−4
Dec., -	4·23	3·54	4·62	5·73	4·90	4·11	4·74	+0·43	27	+7
Whole Year,	40·91	37·95	36·01	36·76	33·57	38·03	32·87	−5·90	190	−10

\+ indicates above, and − below the average.
1 inch Rainfall = 100 tons of water per acre.
* ·01 inch Rainfall constitutes a rainy day.

Table III.

Months.	Rainfall (Inches).							Difference of 1915 from Average of 1901-1915.	Average quarterly rainfall expressed as percentage of whole year, using Average of 1901-1915.
	1909.	1910.	1911.	1912.	1913.	1914.	1915.		
Jan.-Mar.,	9·56	9·79	10·48	9·21	8·65	12·75	10·37	+0·01	26·7
April-June,	9·51	6·54	7·12	6·72	7·81	5·21	5·57	−1·55	18·4
July-Sept.,	10·37	12·49	7·02	7·90	5·42	8·55	8·20	−1·68	25·5
Oct.-Dec.,	11·47	9·22	11·39	12·93	11·69	11·52	8·48	−2·93	29·4
Whole Year,	40·91	37·95	36·01	36·76	33·57	38·03	32·62	−6·15	

Table IV.

Month.	Hours of Bright Sunshine.				Mean Temperature, F.°		Highest Maximum Temperature 1915. F.°	Lowest Minimum Temperature 1915. F.°	Greatest Range of Temperature 1915. F.°
	1915.		Difference of 1915 from Average of 1902-1915.		1915.	Difference of 1915 from Average of 1902-1915.			
	H.	M.	H.	M.					
January,	35	54	+6	47	36·7	−1·8	51	20	31
February,	52	6	+0	16	38·1	−0·7	54	23	31
March,	105	24	+12	41	40·0	−0·8	55	18	37
April,	164	30	+33	13	45·2	+0·9	69	28	41
May,	223	24	+64	58	49·4	−0·3	77	25	52
June,	227	36	+51	15	56·9	+2·8	75	39	36
July,	208	48	+39	42	56·1	−1·1	70	40	30
August,	110	12	−27	2	57·1	+0·65	70	33	37
September,	158	18	+42	48	54·3	+1·2	73	24	49
October,	89	18	+15	34	46·0	−1·9	64	27	37
November,	56	6	+13	14	35·0	−6·2	52	15	37
December,	19	30	−3	37	38·0	−1·7	53	22	31

\+ indicates above, and − below the average.

Table V.

Month.	Occurrence of Frost, 1915.
January, - -	4th, 10th, 17th, 18th, 22nd, 23rd, 24th, 25th.
February, -	15th.
March, - -	27th, 28th, 29th, 30th, 31st.
April, - -	13th.
May, - -	15th.
September, -	28th, 29th, 30th.
October, - -	1st, 16th.
November, -	3rd, 11th, 13th, 17th, 18th, 19th, 20th, 21st, 24th, 26th.
December. -	2nd, 12th, 13th, 18th, 19th.

REMARKS ON THE WEATHER OF EACH MONTH.

January—The first fortnight was very changeable and wet, rain being recorded on practically every day. Thereafter, until the end of the month, more settled conditions prevailed; the days were generally frosty, and there were occasional snow-showers. The rainfall and the number of rainy days were about normal. The mean temperature was 1·8 degrees below, and the amount of bright sunshine a little above the average. Prevailing winds—south-east to south-west. *February*—The weather was unsettled and wet for the greater part of this month, only on the 15th was frost recorded. The rainfall was 1·62 inches above the normal, and there were 21 rainy days. A very heavy rain, causing flooding, occurred on the 26th, when 1·3 inches of rain was registered within the 24 hours. The land was sodden, and ploughing operations were practically at a standstill. Prevailing winds — south. *March*—This month was, fortunately, much drier than that of its predecessor; the rainfall was 1·51 inches below the average. With the wind in the north for the greater part of the month,

and with a good deal of sunny weather the land dried well, and good progress was made with the ploughing. Corn was sown in many cases with the soil in splendid condition. The mean temperature was below, and the bright sunshine much above, the average. Prevailing winds—north-west. *April*—The first half of this month was very showery; ·46 inch fell on the 3rd, and ·57 inch on the 7th. The frequent showers somewhat hindered seeding operations. A slight frost occurred on the 13th. After that date until the end of the month there were few rainy days. During the last four days of the month continuous bright sunshine was recorded. On the whole, the weather was typical for the month of April. Prevailing winds—west and south-west. *May*—The weather for this month was remarkably dry; there were only three days on which rain was recorded. There was a deficiency of 1·61 inches of rain. The total rainfall for the month was ·8 inch, and of that, ·54 inch fell on the 11th. A sharp frost, doing much damage, especially to the potato crop, occurred on the 15th. The bright sunshine was much above the average. The land was in good condition for turnip sowing. Prevailing winds—west and south-west. *June*.—The settled condition which characterised the weather of the last month continued throughout the greater part of June, and but for the heavy showers which occurred on the 4th, 19th, and 26th, the crops would have suffered severely from the droughty conditions. The rainfall was about normal, and fell mostly on the three days mentioned. The temperature and bright sunshine were much above the average. The turnip and hay crops did not promise well. Prevailing winds—east. *July*—The weather for this month was unsettled, and rain was registered on 19 days. The rainfall for the month was 1·16 inches above normal. The frequent showers, and the dull days following the dry weather of the preceding two months had the effect of considerably improving the yield of the hay crop, which was got in in fair condition. Prevailing winds—west and south-west. *August*—The first fortnight of this month was rainy, but from the middle to the end of the month settled conditions prevailed. Harvest became general towards the end of the month, and the crop was quite up to the average. There was a deficiency of 1·34 inches of rain, and a less amount of

bright sunshine than usual. The temperature was normal. Prevailing winds—south-west. *September*—The weather for this month was one of the finest on record for September. The hours of bright sunshine and mean temperature were much above the average. There was a deficiency of 1·59 inches of rain; the total rainfall was 1·12 inches, and of that, ·61 inch fell on the 24th. Frost was recorded on the last three days of the month. Prevailing wind—south-east. *October*—The fine sunny weather of the previous month continued through October. The total rainfall for the month was 2·05 inches, a deficiency of 1·52 inches from the average. Two frosts were recorded, namely, on the 1st and 16th of the month. Prevailing winds—east and south-east. *November*—The abnormally dry weather of the two preceding months was also characteristic of this month; there was a deficiency of 1·83 inches of rain. The total rainfall was 1·69 inches, and of that, ·72 inch were recorded on the 8th. This month was also noticeable for the relatively long and severe spell of frosty weather, lasting from the 11th to the 26th. The mean temperature was 6·2 degrees below the average. Prevailing wind—east. *December*—With the opening of this month the weather broke down, and continued changeable until the end of the year. Frost was registered on five occasions. Snow-showers occurred on the 3rd, 5th, 8th, and 9th. Rainstorms were frequent in the last fortnight. The rainfall for the month was normal. Prevailing wind—east.

The outstanding features of this year were—the deficiency of rain in the early and late spring, when, with the exception of February, each month registered a shortage; a normal mid-summer; an exceptionally dry autumn and early winter. The hay and corn harvests were gathered in in good condition. The deficiency of rain for the year was 5·9 inches.

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West of Scotland Agricultural College.

Principal—W. G. R. PATERSON, B.Sc.
Secretary—JOHN CUTHBERTSON, F.R.S.E.

REPORTS

ON

PIG FEEDING EXPERIMENTS;

ON THE FEEDING OF DAIRY COWS;

ON MEDICINAL PLANTS;

ON FOOD PRODUCTION IN COTTAGE AND ALLOTMENT GARDENS;

ON UTILISATION AND ERADICATION OF BRACKEN;

ON THE TRAINING AND EMPLOYMENT IN RURAL OCCUPATIONS OF DISCHARGED DISABLED SAILORS AND SOLDIERS;

ON EXPERIMENTS ON THE MANURING OF OATS.

FOURTEENTH ANNUAL REPORT.

Copies of this Report will be forwarded (price 1/6, post free) on application to the Secretary.

GLASGOW, 1917.

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15 Jan 13 Exchange

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NOTE OF ACKNOWLEDGMENT.

The Governors of the College have pleasure in expressing their indebtedness to farmers and others who gave facilities for the carrying out of certain of the experiments dealt with in this report, and who incurred much trouble, and not a little expense, in their careful supervision and execution.

BULLETIN No. 75.

West of Scotland Agricultural College.

UNIVERSITY OF GLASGOW LIBRARY

REPORT

ON

PIG FEEDING EXPERIMENTS

CONDUCTED AT

THE COLLEGE FARM, KILMARNOCK,

IN

1914 AND 1915,

BY

WILLIAM G. R. PATERSON, B.Sc., N.D.A.Hons.,
Principal and Professor of Agriculture,

AND

LINDSAY ROBB, C.D.A.D., N.D.A., N.D.D.,
Supervisor of Experiments and Manager of College Farm.

GLASGOW, 1916.

REPORT ON PIG FEEDING EXPERIMENTS.

This Report deals with experiments conducted at the College Farm, Kilmarnock, in 1914 and 1915. The investigation is by no means complete, but the writers are of opinion that the results already obtained are of sufficient importance to warrant the issue of this preliminary Report.

The results should be of interest to all pig feeders, but will prove of special interest to those in cheese-making districts where a large amount of whey is available.

The primary object of the experiment was not to test different rations, **but to ascertain the best method of feeding a particular ration,** there being at the present time great diversity of practice amongst pig feeders. In addition, accurate information was wanted as to the amount of food required to produce 1 lb. live weight increase.

EXPERIMENTAL RATION.

The ration fed to all the pigs consisted of a mixture by weight of three parts maize meal, two parts thirds, and one part barley meal, and this was fed along with whey at the rate of $2\frac{1}{2}$ lbs. meal to 1 gallon of whey. As will be seen later, the actual quantity fed per pig varied with the age of the animal. Only a small quantity was fed to begin with, but this was steadily increased as the animals developed. In the 1915 experiment a small quantity of fish meal was introduced into the ration.

METHOD OF CONDUCTING THE EXPERIMENT.

Home bred pigs (Large White Yorkshire crosses of fairly uniform type) were used for the experiment. They were weaned at the age of eight weeks, and for the next three weeks were fed exactly alike, their ration during that period consisting of thirds, a little maize meal, and whey.

In view of the fact that one object of the experiment was to test different methods of feeding a particular ration, part of the meal was fed dry during the preliminary period, and part was scalded and fed in a moist condition. This, to some extent at least, accustomed the pigs to the food in its different forms, and gave no lot an undue advantage when the experiment proper commenced.

In both seasons 48 pigs were selected and used for the experiment. These were divided into three groups with 16 in each, and so arranged that there was very little difference in the average live weight of the pigs in the different groups.

Individuality of the animal was, to a great extent, eliminated by the fact that there were 16 pigs in each group, and this makes the results much more reliable than if a smaller number of animals had been used.

The building in which the experiment was conducted was set apart entirely for that purpose. It contained 12 pens, approximate size 10½ feet by 9 feet, but as the pens were only provided with trough accommodation for four pigs that was the number put into each.

For the sake of convenience the different experimental groups were designated respectively Lots A, B, and C. Each Lot comprised four pens with four pigs in each.

MANNER OF FEEDING.

In the 1914 experiment the manner of feeding was as follows :—

Lot A.—Meals fed raw and dry.

Lot B.—Meals soaked in whey and fed in a moist condition.

Lot C.—Meals scalded with boiling water and fed in a moist condition.

In view of the results obtained in 1914, a slight change was made in the 1915 experiment, the scheme in that year being as follows :—

Lot A.—Meals fed raw and dry.

Lot B.—Meals fed raw and dry, but part of the mixed meals replaced with fish meal.

Lot C.—Meals scalded with boiling water and fed in a moist condition.

At the commencement of the experiment proper the pigs were eleven weeks old, and the average live weight per pig approximately 40 lbs.

The quantity of meal and whey fed (apart from the whey used in soaking the meal for Lot B, 1914 experiment) per pig per day at this time was :—

Meal, 1½ lbs.

Whey, 6 lbs. (approximately two-thirds of a gallon).

At the end of the experiment the pigs were 27 weeks old, and were then receiving 4½ lbs. of meal and 18 lbs. of whey (approximately 1¾ gallons) per pig per day.

The feeding time-table was as follows :—

6.45 a.m.—One half of the daily allowance of meal, followed by one-third of the daily allowance of whey.

11 a.m.—One-third of the daily allowance of whey.

4.30 p.m.—One-half of the daily allowance of meal, followed by one-third of the daily allowance of whey.

RESULTS OF 1914 EXPERIMENT.

DURATION OF EXPERIMENT, 16 WEEKS.

Lot A.—Meals fed dry.

Weight of the 16 pigs at commencement of experiment, ...	641 lbs.
Average weight, ...	40 lbs.
Weight of the 16 pigs at end of experiment, ...	2,430 lbs.
Average weight, ...	151·8 lbs.
Live weight increase per animal, ...	111·8 lbs.
Average increase per pig per week, ...	7 lbs.

Unfortunately three of the pigs in this lot made rather disappointing gains during the second half of the experiment. But for this fact the average weekly increase would have been considerably higher.

Lot B.—Meals soaked in whey.

Weight of the 16 pigs at commencement of experiment, ...	619 lbs.
Average weight, ...	38·6 lbs.
Weight of the 16 pigs at end of experiment, ...	2,323 lbs.
Average weight, ...	145·1 lbs.
Live weight increase per animal, ...	106·5 lbs.
Average increase per pig per week, ...	6·66 lbs.

Lot C.—Meals scalded and fed in moist condition.

Weight of the 16 pigs at commencement of experiment, ...	641 lbs.
Average weight, ...	40 lbs.
Weight of the 16 pigs at end of experiment, ...	2,329 lbs.
Average weight, ...	145·5 lbs.
Live weight increase per animal, ...	105·5 lbs.
Average increase per pig per week, ...	6·60 lbs.

Summary of Results for 1914.

Lot A.—Average live weight increase per pig per week,	7 lbs.
Lot B.— ,, ,, ,, ,, ,,	6·66 lbs.
Lot C.— ,, ,, ,, ,, ,,	6·60 lbs.

RESULTS OF THE 1915 EXPERIMENT.

Duration of Experiment, 16 Weeks.

Lot A.—Meals fed dry.

Weight of the 16 pigs at commencement of experiment, ...	648 lbs.
Average weight, ...	40·5 lbs.
Weight of the 16 pigs at end of experiment, ...	2,911 lbs.
Average weight, ...	181·9 lbs.
Average live weight increase per animal, ...	141·4 lbs.
Live weight increase per pig per week, ...	8·8 lbs.

Lot B.—Meals fed dry, but $\frac{1}{8}$th by weight of mixed meals replaced with fish meal.

Weight of the 16 pigs at commencement of experiment, ...	645 lbs.
Average weight, ...	40·3 lbs.
Weight of the 16 pigs at end of experiment, ...	3,092 lbs.
Average weight, ...	193·2 lbs.
Average live weight increase per animal, ...	152·9 lbs.
Average live weight increase per pig per week, ...	9·5 lbs.

Lot C.—Meals scalded and fed in a moist condition.

Weight of the 16 pigs at commencement of experiment, ...	645 lbs.
Average weight, ...	40·3 lbs.
Weight of the 16 pigs at end of experiment, ...	2,787 lbs.
Average weight, ...	174·1 lbs.
Average live weight increase per animal, ...	133·8 lbs.
Average live weight increase per pig per week, ...	8·3 lbs.

Summary of Results for 1915.

Lot A.—Average live weight increase per pig per week,	8·8 lbs.
Lot B.— ,, ,, ,, ,, ,,	9·5 lbs.
Lot C.— ,, ,, ,, ,, ,,	8·3 lbs.

NOTES ON THE RESULTS.

It will readily be apparent that the best result was obtained from feeding the mixed meals raw and dry, the results obtained in 1915 confirming those of the 1914 experiment in that respect. The actual difference was not great in either of the years, but that is just what one would naturally expect, in view of the fact that all the pigs were receiving the same mixed meal, though differently treated. Still, what difference there is points to the advisability of feeding the meals raw and dry, and when allowance is made for the fact that this

method involves the minimum of labour and expense in the preparation of the food and the feeding of the pigs, it is quite clear that it is much the best method of feeding the mixed meal used in the experiment. There is considerable advantage in the fact that no time is required in preparing the food, and no fuel needed for cooking it, or for providing hot water for scalding it. Had the results from feeding the meals raw and dry just been equal to those obtained from soaking or scalding the meals, the dry feeding, for the reasons already stated, would still have been the best method. Since the results were actually better the superiority of this method is all the greater.

Where whey is available the dry feeding method has no disadvantages. In the experiment the pigs took readily to the dry meals at the very beginning of the trial, and all along they were fully the most pleasing lots as regards appearance. Visitors to the farm, when asked to pick out the lots of pigs making the best progress, had no hesitation in fixing on the dry fed lots; in fact, the difference in appearance was greater than the difference recorded by the weighbridge.

The 1915 experiment established the fact that the substitution of a small quantity of fish meal ($\frac{1}{8}$th by weight) for an equivalent portion of the mixed meal still further enhanced the feeding value of the dry ration. The best result of all was obtained from the lot of pigs on this ration, the average live weight gain per pig being 9·5 lbs. per week over the whole experimental period (16 weeks), the corresponding gain in the same year for the lot getting the dry meals minus the fish meal being 8·8 lbs. per pig per week.

When the meals were soaked in whey, as in the 1914 experiment (Lot B), the result, while satisfactory, was not so good as from feeding the meals dry. This result is the more surprising, when we consider that the pigs in this lot were actually getting more whey than the others to the extent of that used in soaking the meals.

The progress made by the pigs fed on the scalded meals (Lot C), was slightly better than that made by those receiving the meals soaked in whey, but considerably behind that obtained from the dry feeding method.

In view of the above results one may reasonably conclude that where whey is available, soaking or scalding of meals, such as those used, is quite unnecessary. Instead of improving the feeding value the result is the very opposite, and the soaked or scalded meal is actually of less feeding value than an equivalent quantity of dry meal.

Amount of Meal and Whey required to produce 100 lbs. of Live Weight Increase.

The amount of food required to produce 100 lbs. of live weight increase varied considerably according to the method of feeding, but relatively more meal and whey were consumed for each lb. increase in live weight obtained in the 1914 than in the 1915 experiment. This was because the pigs available for the trial in 1915 were of a better class than those used in 1914, and helps to emphasise the fact that while "feeding" is important, "breeding" is even more important.

The actual quantities of meal and whey required in the 1915 experiment were as follows:—

Lot.	Manner of Feeding.	Food required for 100 lbs. live weight increase.	
		Meal.	Whey.
A, ...	Meals fed raw and dry, ...	237 lbs. ...	950 lbs.
B, ...	Meals fed raw and dry, but $\frac{1}{8}$th by weight of mixed meal replaced with fish meal, ...	220 lbs. ...	880 lbs.
C, ...	Meals scalded, ...	251 lbs. ...	1,004 lbs.

The saving in meal and whey per 100 lbs. live weight increase, when the meals are fed raw and dry instead of scalded and moist, is 14 lbs. of meal and 54 lbs. (approx. $5\frac{1}{2}$ galls.) of whey. The introduction of fish meals effects a further saving to the extent of 17 lbs. of the mixed meals, and 70 lbs. (approx. 7 gallons) of whey.

In the 1914 experiment relatively more meal and whey were required to produce 100 lbs. live weight increase, the chief

reason for the difference being the one already referred to. The actual amount of meal and whey required was as follows :—

Lot.	Manner of Feeding.	Food required per 100 lbs. of live weight increase.	
		Meal.	Whey.
A, ...	Meals fed raw and dry, ...	300 lbs.	... 1,200 lbs.
B, ...	Meals soaked in whey prior to being fed, ...	315 lbs.	... 1,262 lbs.
C, ...	Meals scalded, ...	318 lbs.	... 1,274 lbs.

The saving in meal and whey per 100 lbs. live weight increase when the meal was fed raw and dry instead of scalded and moist, was 18 lbs. of meal, and 74 lbs. (approx. 7½ gallons) of whey.

When the meals were soaked in whey the loss compared with feeding them raw and dry was 15 lbs. of meal per 100 lbs. live weight increase, and 62 lbs. (fully 6 gallons) of whey, exclusive of that used in the soaking of the meals. When allowance is made for this the saving in whey amounts to no less than 73½ gallons of whey, as the meals were soaked in whey at the rate of 1 gallon whey to 5 lbs. of meal.

The foregoing figures show that a considerable saving in food was effected by feeding the mixed meal used in the experiment raw and dry.

They also show that the amount of meal and whey required to produce 1 lb. live weight increase varied from 2·20 lbs. meal and 8·8 lbs. whey (Lot B, 1915 experiment) to 3·18 lbs. meal and 12 lbs. whey (Lot C, 1914 experiment).

Cost at which the Increase in Live Weight was obtained.

The meals used in 1914 were purchased at normal prices, as the experiment was in progress prior to the commencement of the War. In 1915 prices had advanced by about 40 per cent., so this materially affected the cost of the live weight increase. Apart from the price of the meals the cost per lb. live weight increase also varied according to the manner of feeding the mixed meal used in the experiment.

The price per cwt. of the meals used in 1914 and 1915 and the costs per lb. of live weight increase were as follows :—

1914.

Maize meal, ...	6/9 per cwt.
Thirds, ...	5/6 „
Barley meal, ...	8/6 „

Price per cwt. of the meal mixed in the proportion already referred to—6/7½ per cwt.

Cost per lb. live weight increase, allowing 1d. per gallon for the whey consumed :—

	Cost per lb. live weight increase.
Lot A.—Meals fed raw and dry, ...	3·3d.
Lot B.—Meals soaked in whey, ...	4·3d.
Lot C.—Meals scalded.	3·5d.

1915.

Maize meal, ...	10/- per cwt.
Thirds, ...	7/3 „
Barley meal, ...	11/- „
Fish meal, ...	10/- „

Cost of the meal mixed in the proportion already referred to—9/3 per cwt. for Lots A and C; 9/4 per cwt. for Lot B. The addition of the fish meal only slightly increases the price per cwt.

Cost per lb. live weight increase, allowing 1¼d. per gallon for the whey consumed :—

	Cost per lb. live weight increase.
Lot A.—Meals fed raw and dry, ...	3·5d.
Lot B.—Meals fed raw and dry, but ⅛th by weight of mixed meal replaced with fish meal, ...	3·3d.
Lot C.—Meals scalded, ...	3·7d.

CONCLUSIONS THAT MAY BE DRAWN FROM THE EXPERIMENTS.

1. Where whey is available for pig feeding, and is utilised in the proportions referred to, the meals constituting the other part of the ration should be fed raw and dry.

2. Apart from the saving in labour, in fuel, and in time, the pigs make better progress on the dry meals than on scalded or soaked meals. This is the case even when the meals are soaked in whey.

3. A smaller quantity of meal suffices to produce 1 lb. of live weight increase when the meals are fed raw and dry than if soaked or scalded, and consequently the live weight increase is more cheaply obtained by that method.

4. The pigs are more pleasing in general appearance when fed on dry meals than if fed on soaked or scalded meals.

5. The ration of dry meals is greatly improved by the addition of a small quantity of fish meal, and at least one-eighth by weight should replace an equal part of the mixed meals.

BULLETIN No. 76.

The West of Scotland Agricultural College.

A REPORT

ON THE

RESULTS OF EXPERIMENTS

ON

A.—The Feeding of Dairy Cows on Pasture;

B.—The Yield and Composition of Cows' Milk during Lactation;

C.—The Changes in the Composition of Cheddar Cheese during the Process of Ripening;

BY

PROFESSOR BERRY.

GLASGOW:
PRINTED BY ROBERT ANDERSON, 142 WEST NILE STREET.
1916.

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THE FEEDING OF DAIRY COWS ON PASTURE.

Among dairy farmers the opinion is held by some that the supply of grass in the spring and early summer months, on average pastures and in normal years, is sufficient to insure a full yield of milk of good quality, without causing any undue strain on the constitution of the animal, and that the addition of concentrated food adds to the cost of producing the milk without giving a corresponding increase in the yield. In such cases it is also recognised that when the supply and nutritive value of the grass falls off with the advance of the season, additional foods are necessary to keep up the milk yield and to maintain the condition of the animal.

Others hold that a small and increasing allowance of concentrated food is desirable for cows during the whole of the grazing season. In such cases, although the good quality of the spring and early summer pasturage is fully recognised, yet it is not considered that the pasturage alone is sufficient to meet the full requirements for maximum milk production in the case of heavy milkers and newly-calved cows, without causing a certain amount of "lowering" in the condition of the animal. The additional food, moreover, is supposed to counteract, to some extent, the fall in the fat content of the milk which usually follows the turning of the cows out to pasture, and, at the same time, it also permits the pasture to carry a larger head of stock, in addition to receiving certain benefits from manure residues derived from the extra food consumed.

On the other hand, the practice is followed on many cheese-making farms of giving no concentrated food to cows during the grazing season. The cost of milk production is thereby reduced to a minimum, but against this reduction there must be placed a possible loss in the general condition and milk-producing capacity of the animal, which may ensue when the cows, towards the end of the season, depend for their sustenance solely upon the diminishing supply and lower nutritive value of the late summer and autumn grown grass. By reducing the number of stock on the pasture, allowance, to some extent, can be made for the deterioration in the grazing value of the herbage. Experience also indicates that the extra food supplied to cows while on pasture somewhat prolongs the period of lactation, a result which, for well-known reasons, is not considered an advantage on cheese-making farms. Without the extra food the pasture loses the benefit of manure residues, and may, therefore, be subject to a certain amount of exhaustion, unless precautions to avoid that result are taken.

It is evident from these general observations that there must be a wide diversity of opinion among dairy farmers as to the advantage or otherwise of supplying extra food to cows during the grazing season. It was, therefore, with the purpose of providing more data on this point that the experiment described in this report was carried out.

The Object of the Experiment was, primarily, to determine what would be the effect on the milk yield of giving a small daily allowance of concentrated food to cows on pasture during the summer months, commencing about the middle of July. The effect of supplying the extra food during the whole of the grazing season was to be tested after the completion of the present experiment, but this latter experiment had, unfortunately, to be postponed, owing to the difficulty of carrying on investigations of this kind under the present unprecedented conditions.

The General Scheme of the Experiment.

The experiment was carried out at Holmes Farm, Kilmarnock, and at several centres in the West of Scotland. The intention was to repeat the experiment at each of the centres for three successive years, and, if possible, with the same cows, but this latter idea was afterwards found to be impracticable. The experiment commenced in the summer of 1912, and was continued in the two summers following.

The names of the centres in the different years are—

1912.

The Experiment Station, Holmes Farm, Kilmarnock.
Mr. George Will, The Crichton Royal Farm, Dumfries.
Mr. Robert Stevenson, Boghead, Galston.
Mr. George M'Harg, Laigh Grange, Maybole.

1913.

The Experiment Station, Holmes Farm, Kilmarnock.
Mr. George Will, The Crichton Royal Farm, Dumfries.
Mr. Robert Stevenson, Boghead, Galston.
Mr. James Smith, Mains of Twynholm, Twynholm.
Mr. James Wyllie, Glassock Farm, Fenwick.

1914.

The Experiment Station, Holmes Farm, Kilmarnock.
Mr. George Will, The Crichton Royal Farm, Dumfries.
Mr. Robert Stevenson, Boghead, Galston.
Mr. James Smith, Mains of Twynholm, Twynholm.
Mr. James Wyllie, Glassock Farm, Fenwick.
Mr. Gavin Hamilton, Auldtoun, Lesmahagow.

A Preliminary Test, lasting one month, was carried out at each centre. Its object was to furnish data respecting the cows likely to be suitable for the experiment proper, and, at the same time, it enabled each experimenter to become

thoroughly acquainted with the practical details of the scheme. About twenty cows, of the Ayrshire breed, calving in the spring and early summer months, and excluding queys, were considered necessary at each centre. The cows selected were kept on pasture day and night with the rest of the herd. No additional foods were given, and the cows were all treated alike. The morning and evening milk of each cow was weighed daily, and the percentage of butter-fat was determined weekly.

Every precaution was taken to ensure thoroughness and regularity in the milking, the weighing, and the sampling of the milk. At the same time, all circumstances likely to affect the result of the experiment, such as changing the milkers or the hours of milking, change of pasture, indisposition, sexual excitement, the weather, &c., were recorded.

As a result of the preliminary test, sixteen cows, in most cases, were found suitable at each centre, and this number, when available, was therefore decided upon for the experiment proper.

The Experiment Proper started about the middle of July of each year, and lasted three months; but daily weighings of the milk were afterwards continued until a number of the cows were "dry." The cows selected at each centre were grouped into two lots, there being generally eight cows in a lot. The grouping of the cows was a matter of some difficulty, and required very careful adjustment. The data upon which the grouping was based were :—Date of last calving, date of last service, milk yield, age, percentage of butter-fat, record of previous lactations, and approximate live weight. Working upon these lines, it was possible to arrange the cows into two lots, as comparable as possible in most respects.

The accuracy of the experiment depended almost entirely upon a successful grouping of the cows into two equally balanced lots. Unless this could be accomplished satisfactorily with the data available, the experimental error arising therefrom might, for obvious reasons, be considerably greater than the difference which the experiment was designed to measure. However, by exercising care, first in the

selection, and afterwards in the grouping of the animals, as was done in the present case, and by employing in the experiment as large a number of suitable animals as possible, the error was diminished to a considerable extent. In the case of feeding experiments with cattle, the experimental error for one animal is found to be about 14 per cent. of the live weight increase; but when the milk yield, in place of live weight increase, is taken as the basis of comparison, it is conceivable that the error for one animal might be even greater. However, the writer is accumulating evidence upon this point. Whenever a cow dropped out of the experiment through illness, or some other cause, a cow in the opposite group was also removed, with the minimum of disturbance to the balance of the two groups.

The error due to the general conduct and management of the experiment is one which can be kept within fairly narrow limits, because, in this case, the error is within the control of the experimenter himself, and its dimension will, of course, depend upon a strict adherence, or otherwise, to instructions.

Both lots of cows were treated exactly alike, except that the cows in Lot B received 2 lbs. of concentrated foods daily in the first month, and 4 lbs. in the second and third months of the experiment. One-half of the allowance was given in the byre at the morning milking, and the remainder at the evening milking. The cows were run on the pasture day and night with the rest of the herd.

The Concentrated Food consisted of a mixture of equal parts of decorticated cotton cake and soya bean cake. These two cakes were chosen, because, at the commencement of the experiment, they provided one of the cheapest sources of food units.

It was not considered as part of the experiment to test any specific effect which the cakes might have on the quality of the milk and milk products. Both cakes were nutted, and were given in the dry state. Their analyses are given in Table I, page 20.

TABLE I.

	Decorticated Cotton Cake.				Soya Bean Cake.			
	1912.	1913.	1914.	Average.	1912.	1913.	1914.	Average.
Moisture, - -	9·28	8·36	8·74	**8·80**	10·42	9·70	13·48	**11·20**
Crude Oil, - -	7·82	9·43	8·54	**8·60**	6·55	5·50	5·93	**6·00**
Crude Protein, -	42·25	39·72	40·95	**40·97**	42·06	43·40	41·18	**42·21**
Carbohydrates, -	25·69	24·37	26 59	**25·55**	29·57	30·93	28·75	**29·75**
Crude Fibre, -	8·08	9·85	8·45	**8·79**	5·88	4·87	5·13	**5·29**
Ash, - - -	6·88	8·27	6 73	**7·29**	5·52	5·60	5·53	**5·55**
	100·0	100·0	100·0	**100·0**	100·0	100·0	100·0	**100·0**
Cost of Cake per ton, - -	£ s. d. 9 5 0	£ s. d. 9 2 6	£ s. d. 9 5 0	£ s. d. **9 4 2**	£ s. d. 8 5 0	£ s. d. 8 7 6	£ s. d. 9 0 0	£ s. d. **8 10 1**

So far as one could tell, the cows as a rule showed an equal partiality for the cakes. In a few cases there was some hesitation at first in taking to the cakes, but this, however, was soon overcome, except in one case where a cow persistently refused to take the cakes, although every means of persuasion was tried. She had, in consequence, to be replaced by another cow. The increase from two to four pounds was made gradually.

The Result of the Preliminary Test is summarised in Table II, page 22. As already explained, the data available from this test provided a basis upon which to group the cows. The grouping was done in consultation with the experimenters, whose knowledge of the individual cows was indispensable. It was impossible always to avoid giving a slight advantage to one or other of the lots, but, when this was the case, the advantage was generally, though not always, given to the cows in Lot A. In balancing the effect due to the date of last calving, allowance was always made for the effect due to date of pregnancy. At most centres eight cows were selected for each lot in the actual experiment, but in some cases fewer than that number were available.

TABLE II.
Results of Preliminary Test.

Name of Centre.	Lot A.				Lot B.			
	Age.	Days earlier calving for each lot per Centre.	Average Daily Yield of Milk per Cow in Lbs.	Milk-Fat.	Age.	Days earlier calving for each lot per Centre.	Average Daily Yield of Milk per Cow in Lbs.	Milk-Fat.
1912.	Years.			Per cent.	Years.			Per cent
Holmes Farm, -	7·4	...	35·2	3·6	6·9	30	35·5	3·4
Crichton Royal, -	5·6	...	29·5	3·4	6·0	22	29·9	3·5
Boghead, - -	5·7	7	33·9	3·7	5·6	...	33·8	3·7
Laigh Grange, -	6·9	6	32·5	3·4	7·5	...	32·2	3·4
Average for each Centre,	**6·4**	...	**32·8**	**3·5**	**6·5**	**9·8**	**32·8**	**3·5**
1913.								
Holmes Farm, -	6·5	22	39·1	3·6	5·7	...	39·5	3·5
Crichton Royal, -	6·3	...	30·7	3·6	7·4	24	31·0	3·4
Boghead, - -	5·8	14	34·4	3·6	5·5	...	35·0	3·7
Mains of Twynholm,	6·0	...	39·0	3·4	5·8	6	39·3	3·4
Glassock, - -	6·8	29	35·8	3·5	6·2	...	35·4	3·1
Average for each Centre,	**6·3**	**7**	**35·8**	**3·5**	**6·1**	...	**36·0**	**3·4**
1914.								
Holmes Farm, -	7·8	...	32·4	3·7	6·6	4	32·9	3·6
Crichton Royal, -	5·4	6	31·6	3·7	6·0	...	31·2	3·6
Boghead, - -	5·8	3	36·3	3·9	5·7	...	35·7	3·5
Mains of Twynholm,	6·5	7	32·9	3·4	6·0	...	32·9	3·4
Glassock, - -	6·7	16	34·2	3·3	5·3	...	34·3	3·4
Auldtoun, - -	6·3	...	39·0	3·3	5·2	16	38·9	3·4
Average for each Centre,	**6·4**	**2**	**34·4**	**3·6**	**5·8**	...	**34·3**	**3·5**
Averages for each of the Three Years,								
1912,	**6·4**	...	**32·8**	**3·5**	**6·5**	**9·8**	**32·8**	**3·5**
1913,	**6·3**	**7**	**35·8**	**3·5**	**6·1**	...	**36·0**	**3·4**
1914,	**6·4**	**2**	**34·4**	**3·6**	**5·8**	...	**34·3**	**3·5**
Final Average, -	**6·4**	...	**34·33**	**3·5**	**6·1**	...	**34·36**	**3·5**

The Result of the actual Experiment is summarised in the following tables. When compiling the tables, unnecessary detail was avoided, otherwise, owing to the large accumulation of figures during the three years in which the experiment was in progress, the report would have become unwieldy in size and costly to print.

The milk yield is taken as the basis of comparison of the two lots, the assumption being that the two lots of cows were equal in milk-producing capacity at the commencement of the experiment. But although the greatest care was taken in the grouping of the cows, it is impossible to say that every cow chosen would continue normal in her milk yield throughout her lactation, although she may have behaved quite regularly in her previous lactations. The error due to abnormal tendencies in individual animals is, however, considerably reduced in the present experiment, owing to the large number of cows employed and available for the final averaging. Too much stress must not be placed upon the figures giving the fat content of the milk, because, as already pointed out, only weekly determinations were made in the first year, whilst in the last two years it was only possible to arrange for fortnightly tests.

The Monthly Results.

Table III, page 24, contains the total yield of milk per month for the cows in Lots A and B, respectively, during the three months of the actual experiment for each centre, and for each of the three years of the experiment, also the milk increases of Lot B over Lot A for the different centres for each of the three years.

TABLE III.

Comparison of the Monthly Yield of Milk at each Centre, in lbs. by weight.

Name of Centre.	1st Four Weeks.			2nd Four Weeks.			3rd Four Weeks.			Number of Cows in each Lot at the commencement of the
	Total Yield of Milk.		Increase of Lot B over Lot A.	Total Yield of Milk.		Increase of Lot B over Lot A.	Total Yield of Milk.		Increase of Lot B over Lot A.	
	Lot A.	Lot B.		Lot A.	Lot B.		Lot A.	Lot B.		
1912.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
Holmes Farm, -	6692	7138	446	5807	6401	594	3947	4847	900	8
Crichton Royal,-	5665	5565	–100	4499	4847	348	3251	3919	668	7
Boghead, - -	6968	7148	180	5942	6192	250	5109	5407	298	8
Laigh Grange, -	6309	6677	368	4284	4805	521	2941	3696	755	8
Average for each Centre.	**6408**	**6632**	**224**	**5133**	**5561**	**428**	**3812**	**4467**	**655**	
1913.										
Holmes Farm, -	6950	7360	410	5828	6399	571	3581	4772	1191	8
Crichton Royal,-	5975	6480	505	4693	5231	538	3534	4204	670	8
Boghead, - -	6951	6817	–134	5575	5798	223	5012	4815	–197	8
Mains of Twynholm,	6979	7506	527	4857	5555	698	3269	4180	911	8
Glassock, - -	7192	7698	506	6479	7233	754	5290	6029	739	8
Average for each Centre.	**6809**	**7172**	**363**	**5486**	**6043**	**557**	**4137**	**4800**	**663**	
1914.										
Holmes Farm, -	4166	4731	575	3774	4442	668	2989	4026	1037	
Crichton Royal,-	4145	3989	–156	3230	3180	– 50	2488	2666	178	
Boghead, - -	6967	7054	87	5960	6041	81	4906	5147	241	
Mains of Twynholm,	6329	7058	729	5379	6186	807	4275	4898	623	
Glassock, - -	6952	7344	392	5876	6093	217	5257	5507	250	
Auldtown,- -	4294	4351	57	3691	3809	118	2624	3249	625	
Average for each Centre,	**5475**	**5755**	**280**	**4652**	**4958**	**306**	**3756**	**4249**	**493**	
Averages for each of the Three Years.										
1912,	**6408**	**6632**	**224**	**5133**	**5561**	**428**	**3812**	**4467**	**655**	
1913,	**6809**	**7172**	**363**	**5486**	**6043**	**557**	**4137**	**4800**	**663**	
1914,	**5475**	**5755**	**280**	**4652**	**4958**	**306**	**3756**	**4249**	**493**	
Final Average,	**6231**	**6520**	**289**	**5090**	**5520**	**430**	**3902**	**4505**	**603**	

One Gallon of Milk = 10·32 Lbs.

The figures in this table show that the concentrated food consumed on the pastures produced a progressive increase in milk yield for each month in favour of Lot B at most of the centres. In round figures the increase in favour of each of the cows receiving the extra food amounted on an average to a little under one gallon of milk per week in the first month, to a little less than one and a quarter gallons per week in the second month, and to nearly two gallons per week in the third month of the experiment. The increases varied considerably at each centre. As a rule the increases were highest at Holmes Farm and lowest at Boghead.

By calculating the increases to percentages, which is done in Table IV, page 26, the comparative effect of the additional foods is more readily shown.

TABLE IV.

Comparison of the Monthly Yield of Milk at each Centre, in percentages.

Name of Centre.	Increase of Lot B over Lot A, in Percentages.		
	1st Four Weeks.	2nd Four Weeks.	3rd Four Weeks.
1912.			
Holmes Farm, - -	6·7	10·2	22·8
Crichton Royal, - -	– 1·7	7·7	20·5
Boghead, - - -	2·6	4·2	5·8
Laigh Grange, - -	5·8	12·2	25·7
Average for each Centre,*	**3·5**	**8·3**	**17·2**
1913.			
Holmes Farm, - -	5·9	9·8	33·3
Crichton Royal, - -	8·5	11·5	18·9
Boghead, - - -	– 1·9	4·0	— 3·9
Mains of Twynholm, -	7·5	14·4	27·8
Glassock, - - -	7·0	11·6	14·0
Average for each Centre,*	**5·3**	**10·1**	**16·0**
1914.			
Holmes Farm, - -	13·6	17·7	34·7
Crichton Royal, - -	– 3·8	– 1·5	7·2
Boghead, - - -	1·2	1·4	4·9
Mains of Twynholm, -	11·5	15·0	14·6
Glassock, - - -	5·6	3·7	4·8
Auldtown, - - -	1·3	3·2	23·7
Average for each Centre,*	**5·1**	**6·6**	**13·1**
Averages for each of the Three Years,			
1912,	**3·5**	**8·3**	**17·2**
1913,	**5·3**	**10·1**	**16·0**
1914,	**5·1**	**6·6**	**13·1**
Final Average, - -	**4·6**	**8·3**	**15·4**

* The yield of milk obtained at each centre is added together and the percentages calculated from the totals.

The average figures in this table leave no doubt as to what has been the effect on the milk yield of supplementing the grass with concentrated food during the latter part of the grazing season. In the first month of the experiment the increase amounted on an average to about 4·5 per cent. of the month's yield of milk; in the second month to about 8·5 per cent.; and in the third month to about 15·5 per cent. The drop in the milk yield each month for the same periods, and due mainly to the advance in lactation and gestation, was, on the average—for Lot A, 13·5 per cent., 18·5 per cent., and 23 per cent.; for Lot B, 12 per cent., 15·5 per cent., and 18·5 per cent., respectively. The decrease was therefore more rapid in the case of the cows receiving no extra food on the pastures.

Although the figures obtained at the different centres vary, as a rule they all bear the same general interpretation, namely, that the effect on the milk yield of supplying additional food to cows on the pasture, commencing in the middle of July, is slight at first, but becomes more pronounced as the season advances.

In the case of the 1913 experiment at Boghead the result is indefinite. The inclusion of an exceptionally heavy milking cow in Lot A largely accounted for this. Also, in the 1914 experiment at the Crichton Institution an adverse result was obtained from the feeding in the first two months. In this case two cows from each lot dropped out long before the completion of the experiment, and, as their figures had to be discarded from the commencement, the balance of the groups was to some extent interfered with. However, the final result, as will be seen from the figures, is in general agreement with that obtained at other centres.

The Results for the Three Months.

In the foregoing tables the monthly figures only have been considered. In Table V, page 28, the completed figures for the whole of the three months are summarised, and they include the average weekly yield of milk per cow in Lots A and B respectively, the total yield of milk for both lots at each of the centres, and the increases of Lot B over Lot A, in lbs. of milk and in percentages.

TABLE V.

Comparison of the Total Yield of Milk, in lbs. by weight, and in percentages, at each Centre.

Name of Centre.	Result of Actual Experiment lasting 12 Weeks and Commencing about 15th July in each Year.					
	Average Yield of Milk in Lbs. per Cow per Week.		Total Yield of Milk in Lbs.		Increase of Lot B over Lot A.	
	Lot A.	Lot B.	Lot A.	Lot B.	Lbs. Milk.	Per-centage.
1912.						
Holmes Farm, - -	171·3	191·5	16,446	18,386	1,940	11·8
Crichton Royal, -	159·7	170·6	13,415	14,331	916	6·8
Boghead, - - -	187·7	195·2	18,019	18,747	728	4·0
Laigh Grange, - -	152·4	171·0	13,534	15,178	1,644	12·1
Average, - -	**167·8**	**182·1**	**15,353**	**16,660**	**1,307**	**8·5**
1913.						
Holmes Farm, - -	170·4	193·0	16,359	18,531	2,172	13·3
Crichton Royal, -	148·0	165·8	14,202	15,915	1,713	12·1
Boghead, - - -	182·7	181·6	17,538	17,430	– 108	– 0·6
Mains of Twynholm,	172·4	196·8	15,105	17,241	2,136	14·1
Glassock, - - -	197·5	218·3	18,961	20,960	1,999	10·6
Average, - -	**174·2**	**191·1**	**16,432**	**18,015**	**1,583**	**9·6**
1914.						
Holmes Farm, - -	151·8	183·3	10,929	13,199	2,270	20·7
Crichton Royal, -	137·0	136·6	9,863	9,835	– 28	– 0·3
Boghead, - - -	185·8	190·0	17,833	18,242	409	2·3
Mains of Twynholm,	166·5	189·0	15,983	18,142	2,159	13·5
Glassock, - - -	188·4	197·3	18,085	18,944	859	4·8
Auldtoun, - -	176·8	190·1	10,609	11,409	800	7·5
Average, - -	**167·7**	**181·1**	**13,883**	**14,962**	**1,079**	**7·8**
Averages for each of the Three Years,						
1912,	167·8	182·1	15,353	16,660	1,307	8·5
1913,	174·2	191·1	16,432	18,015	1,583	9·6
1914,	167·7	181·1	13,883	14,962	1,079	7·8
Final Average,	**169·9**	**184·8**	**15,223**	**16,545**	**1,322**	**8·7**

The averages do not always represent the same number of cows, and they are, therefore, not comparable in every case. The average results seem to show that the heavier milking cows are, on the whole, the more responsive to the extra feeding, a result which would be in accordance with expectation, but when the figures for individual centres are examined the evidence is not clear. However, the question is complicated in the present case by the intervention of other factors.

The figures contained in the last column bring out the difference in milk return yielded by the concentrated foods during the twelve weeks of the experiment. The return amounted to an increase of between 8 and 9 per cent. The individual centres again show the same considerable variation.

By spreading the total milk increase over the three months of the experiment, which is done by dividing the respective monthly increases by the total yield of milk produced for the whole period, a similar result to that already emphasised in Table V is reached. The figures are given in the following Table VI.

TABLE VI.

Year.	Average Increase of Lot B over Lot A for each of the three years, in Percentages.			
	1st Four Weeks.	2nd Four Weeks.	3rd Four Weeks.	Total for the Three Months.
1912,	1·4	2·8	4·3	8·5
1913,	2·2	3·4	4·0	9·6
1914,	2·0	2·2	3·6	7·8
Average for the Three Years,	1·9	2·8	4·0	8·7

Stated in whole numbers, the effect of the additional food on the total milk production of the cows on the pasture, during the summer grazing, amounted on an average to an increase in milk yield of about 2 per cent in the first month, about 3 per cent. in the second month, and to about 4 per cent. in the third month.

Turning to the *fat content of the milk* the average figures are given in Table VII, page 30.

TABLE VII.

Average Percentages of Milk Fat per Month at each Centre.

Name of Centre.	Lot A.				Lot B.			
	Milk-Fat Percentages.				Milk-Fat Percentages.			
	1st Month.	2nd Month.	3rd Month.	Average.	1st Month.	2nd Month.	3rd Month.	Average.
1912.								
Holmes Farm, - -	3·7	3·9	4·1	**3·9**	3·4	3·5	3·7	**3·5**
Crichton Royal, -	3·4	3·7	3·8	**3·6**	3·6	3·9	4·1	**3·8**
Boghead, - - -	3·7	4·2	4·3	**4·1**	3·8	3·8	4·1	**3·9**
Laigh Grange, - -	3·6	3·7	4·1	**3·8**	3·5	3·8	4·3	**3·9**
Average, - -	**3·6**	**3·9**	**4·1**	**3·9**	**3·6**	**3·8**	**4·0**	**3·8**
1913.								
Holmes Farm, - -	3·6	3·7	4·3	**3·9**	3·4	3·5	3·9	**3·6**
Crichton Royal, -	3·7	4·0	4·6	**4·1**	3·6	3·9	4·1	**3·9**
Boghead, - - -	3·8	4·1	4·3	**4·1**	3·8	4·1	4·4	**4·1**
Mains of Twynholm,	3·5	3·9	4·1	**3·8**	3·5	3·9	4·0	**3·8**
Glassock, - - -	3·5	3·6	4·3	**3·8**	3·1	3·2	4·0	**3·4**
Average, - -	**3·6**	**3·9**	**4·3**	**3·9**	**3·5**	**3·7**	**4·1**	**3·8**
1914.								
Holmes Farm, - -	3·7	4 0	4·5	**4·1**	3·6	3·7	3·9	**3·7**
Crichton Royal, -	3·6	3·8	4·8	**4·1**	3·7	4·1	4·6	**4·1**
Boghead, - - -	3·9	4·0	4·2	**4·0**	3·4	3·5	3·6	**3·5**
Mains of Twynholm,	3·6	3·7	4·0	**3·8**	3·5	3·8	3·8	**3·7**
Glassock, - - -	3·3	3·6	3·9	**3·6**	3·5	3·6	3·9	**3·7**
Auldtown, - -	3·3	3·4	3·5	**3·4**	3·5	3·7	3·7	**3·6**
Average, - -	**3·6**	**3·8**	**4·2**	**3·9**	**3·5**	**3·7**	**3·9**	**3·7**
Averages for each of the Three Years,								
1912,	**3·6**	**3·9**	**4·1**	**3·9**	**3·6**	**3·8**	**4·0**	**3·8**
1913,	**3·6**	**3·9**	**4·3**	**3·9**	**3·5**	**3·7**	**4·1**	**3·8**
1914,	**3·7**	**3·8**	**4·2**	**3·9**	**3·5**	**3·7**	**3·9**	**3·7**
Final Average, -	**3·6**	**3·9**	**4·2**	**3·9**	**3·5**	**3·7**	**4·0**	**3·7**

It would appear at first that the effect of the feeding of the concentrated food to cows on the pastures was to depress the fat content of the milk, because the rise in the percentage of fat during the course of the experiment seems to be more pronounced in the case of the cows receiving grass only. The action of the extra feeding in prolonging the period during which the cows remain in milk, and thereby influencing the composition and the yield of milk, seems to explain this result.

Table VIII gives an indication of the extent to which the period of lactation was influenced by the extra feeding.

TABLE VIII.

Year.	Lot A.		Lot B.	
	Yield of Milk in Lbs. per day at the finish of the Experiment.	Average Lactation in weeks for each Cow for the period of the Experiment.	Yield of Milk in Lbs. per day at the finish of the Experiment.	Average Lactation in weeks for each Cow for the period of the Experiment.
1912,	10·0	16·1	12·1	17·0
1913,	9·4	18·5	9·5	19·1
1914,	8·5	17·5	9·0	18·3
Average,	9·3	17·4	10·2	18·1

No reference, so far, has been made as to the cause of variation in the milk increases produced by the feeding of the concentrated food on the pastures at the different centres. As already pointed out, the increased yield in each year was highest at Holmes Farm, and lowest at Boghead—a fact which indicates the existence of a distinct but definite set of conditions persisting at each of the centres named.

Before making comparisons, however, it is necessary to satisfy oneself that the results are sufficiently reliable to justify conclusions being drawn from them. The experimental error in the case of the average figures is, in all probability, relatively small, owing to the fact that (*a*) the total number of cows employed in the experiment was 224; (*b*) the grouping of the cows into two equally balanced lots was approximately very close, as shown in Table II, page 22; and (*c*) by repeating the experiment fifteen times within three years, results were obtained which all bear the same general interpretation.

Where individual centres are concerned, and a smaller number of cows are being dealt with, there is less scope for equalising the chances of error; but, as previously pointed out, every precaution was taken to reduce the error to as small a figure as possible. The figures supplied by the two centres just referred to show that the general conditions prevailing in each case are consistently reflected each year in the results. Had the error been large, such agreement in the yearly results at any one centre could hardly have been expected.

The Average Results.

Considering the results first as a whole, the outstanding feature common to each centre is the effect which the advance of summer has had on the response in milk yield, due to the extra feeding. In practically every case the figures show a progressive increase in milk return. The inference to be drawn is that the pasturage, even from the beginning of the experiment, about the middle of July, fails to supply all the requirements for a maximum milk production, because, in the first month, a small allowance of additional food produces a small increase in milk yield. As the season advances, the discrepancy between the milk-producing capacity of the pasturage and the amount of food which can evidently be utilised with advantage by the cow is indicated by the increasing efficiency of the concentrated food. The same weight of food produced, on an average, an increase of 8·5 per cent. of

the month's yield of milk for the second month of the experiment, compared with 15·5 per cent. for the third month. The diminished supply and lower nutritive value of the herbage largely accounted for this, but colder nights and lower day temperatures would also contribute.

With the fall in the milk yield, due to the advance in lactation,* the requirements of the cow become less, but, at the same time, as the process of gestation proceeds other demands increase. Foetal growth has been shown not to affect the milk yield until from 12 to 16 weeks have elapsed since the date of service, and the fall, when it commences, follows much the same order as the fall due to lactation, in absence of gestation. One of the effects of the extra feeding, in the present case, has been to prolong the period of activity of the mammary glands. In fact, the difference between the milk yields of the two lots is due to the difference in the respective rate of fall, the difference being intensified as the season advances (see page 24). Other means of prolonging the lactation are well known. Shorter lactations, such as are favoured on cheese-making farms, even when shortened by reduced food supplies, have the advantage of a longer period during which the cows remain dry. The position is reversed in the case of longer lactations, which latter are aimed at on milk-selling farms.

Unless adequate food supplies are available, the condition of the cow on the pastures would suffer, especially in the later stages of gestation. The effect which such a result might have on the health of the cow and its progeny, and on the subsequent lactations, is a matter difficult to estimate. It was intended in the present experiment to furnish data upon this point, by employing, as far as possible, the same cows, in the same group, each year of the experiment.

It was not practicable to take the live weight of the animals at the beginning of the experiment, as was originally intended. Had this been done, some data with a definite bearing upon the condition of the animal would have been available. How-

* *Ibid.* "Result of Experiment on the Yield and Composition of Cows Milk during Lactation," page 49.

ever, it was the opinion of each of the experimenters that the condition of the cows in both lots was much the same at the end of the experiment at all the centres.

As to whether the allowance of concentrated food supplied is sufficient, or as to whether additional food should have been given throughout the whole of the grazing season, the results do not conclusively prove. A profit and loss account, based upon the milk yield alone, is given in Table XI, page 38.

The Results at each Centre.

In a comparison of the individual centres, the cause of variation in the effect of the concentrated foods must be attributed mainly to the difference in the quality and supply of the pasturage, and to the relative number of stock which the pasture is made to carry. The average carrying capacity for summer grazing of ten acres of the pasture-land, at the different centres, has been supplied by each of the experimenters, and the figures are given in Table IX.

TABLE IX.

Name of Centre.	Number of Cows which 10 Acres of Pasture-land will carry for Summer Grazing.
Holmes Farm, - -	10
Crichton Royal, -	8
Boghead, - - -	8
Mains of Twynholm, -	8
Glassock, - - -	4 to 5
Auldtoun, - - -	7
Laigh Grange, - -	5

The table provides a comparison of the grazing value of the respective pastures, on the basis of the usual custom of stocking followed at each centre. No analysis of the grass was attempted, nor, of course, was it possible to obtain any data as to the weight of grass available or consumed daily by each cow. It may, however, be assumed that where the action of the concentrated food was most effective it was due to a combination of causes—such as a scarcity of pasturage, a deficiency in some respect in the nutritive material supplied by the grass, to colder nights, and to the relative degree of stocking of the pasture.

In 1912 the months of September and October were dry, and at Laigh Grange there was undoubtedly a shortage of grass towards the end of the experiment. This centre, in the last month of the experiment, gave the largest return of any for the extra feeding. The farm of Boghead lies low, and the pasture-land for this reason is not subject to great seasonal variation. The weather, as recorded at Kilmarnock during the three years of the experiment, was in some ways exceptional. In the year 1912 a shortage of rain was registered for each of the months of September and October, and in the years 1913 and 1914 the late summer and autumn months were unusually dry (see Table X). Considerable distances separated some of the centres, and it does not, therefore, follow that the weather conditions at Kilmarnock are representative, except in a very general sense. Type of soil, elevation, exposure, botanical nature of the herbage, along with the climate, constitute the local conditions which determine the supply and quality of the pasturage at any one centre. The management of the pasture and its effects must also be included.

TABLE X.

Month.	Rainfall (Inches).					
				Difference from Average.		
	1912.	1913.	1914.	1912.	1913.	1914.
January, -	2·14	3·01	3·91	− 1·62	− 0·70	+ 0·91
February,	2·19	1·92	4·43	− 1·03	− 1·20	+ 1·22
March, -	4·88	3·72	4·41	+ 1·56	+ 0·37	+ 0·99
April, -	1·98	2·35	2·62	− 0·59	− 0·21	+ 0·07
May, -	1·16	2·81	1·83	− 1·40	+ 0·23	− 0·69
June, -	3·58	2·65	0·76	+ 1·35	+ 0·39	− 1·39
July, -	2·29	1·48	2·32	− 0·76	− 1·44	− 0·56
August, -	2·96	1·52	4·33	− 1·56	− 2·78	+ 0·04
September,	2·65	2·42	1·90	− 0·29	− 0·48	− 0·92
October, -	3·64	1·91	2·37	− 0·30	− 1·87	− 1·31
November,	3·56	4·88	5·04	+ 0·12	+ 1·33	+ 1·39
December,	5·73	4 90	4·11	+ 1·48	+ 0·61	− 0·17
Whole year,	36·76	33·57	38·03	− 3·04	− 5·75	− 0·42

+ Indicates above and − below the average.

The question of quality, apart from the effect of age, in pasturage, as in other vegetable foods, is not altogether fully explained in an ordinary chemical analysis, by determining the percentages of those constituents which usually provide the basis of valuation. Other factors which have been disclosed during the last decade as a result of biochemical research, may alter appreciably our conception of what constitutes a complete food ration. But as to whether the subject has any direct practical bearing or significance in helping to explain the cause of variation in the quality of pasturage, and the influence of season, and stage of growth thereon, it is not possible, in the meantime, to say. In any case, it is well known that the process of milk secretion is peculiarly susceptible to certain influences, pasturage being one of them. In connection with the mineral content of pasture-grass, the writer is accumulating evidence which points to a direct relationship between the mineral constituents of pastures and texture in cheese, apart altogether from the predominating influence of the personal and the biological factors in cheese-making. Some data bearing upon these points are also given in the results of the experiment on "The Yield and Composition of Cows' Milk during Lactation," page 49.

The Profit and Loss.

As to whether it is profitable to supplement pasturage with concentrated foods, the figures in Table XI, page 38, give some information on this point. In this table the milk increase is valued at 8d. per gallon, and against this is debited the cost of the food consumed—the difference is the profit or loss.

TABLE XI.

Comparison of the Value of the Milk Increase and the Cost of t Cake consumed.

Name of Centre.	Total Increase of Milk of Lot B over Lot A.	Value of Milk at 8d. per Gallon.	Cost of Cake used.	Difference between the value of the Milk and the Cost of the Cake.	Numbe Cows each Lo the co mencer of the perio
1912.	Lbs.	£ s. d.	£ s. d.	£ s. d.	
Holmes Farm, - -	1,940	6 9 4	8 15 0	−2 5 8	8
Crichton Royal, - -	916	3 1 1	7 13 2	−4 12 1	7
Boghead, - - -	726	2 8 5	8 15 0	−6 6 7	8
Laigh Grange, - -	1,646	5 9 9	7 17 6	−2 7 9	8
Average for each Centre,	1,307	4 7 2	8 5 2	−3 18 0	...
1913.					
Holmes Farm, - -	2,172	7 4 9	8 15 0	−1 10 3	8
Crichton Royal, - -	1,713	5 14 3	8 15 0	−3 0 9	8
Boghead, - - -	...	...	8 15 0	−8 15 0	8
Mains of Twynholm, -	2,135	7 2 5	7 16 5	−0 14 0	8
Glassock, - - -	2,000	6 13 4	8 15 0	−2 1 8	8
Average for each Centre,	1,604	5 7 0	8 11 4	−3 4 4	..
1914.					
Holmes Farm, - -	2,270	7 11 4	6 16 11	+0 14 5	6
Crichton Royal, - -	...	...	6 16 11	−6 16 11	6
Boghead, - - -	408	1 7 3	9 2 6	−7 15 3	8
Mains of Twynholm, -	2,160	7 4 0	9 2 6	−1 18 6	8
Glassock, - - -	860	2 17 4	9 2 6	−6 5 2	8
Auldtown, - - -	799	2 13 3	5 14 1	−3 0 10	5
Average for each Centre,	1,083	3 12 2	7 16 0	−4 3 10	..
Average for each of the Three Years.					
1912,	1,307	4 7 2	8 5 2	−3 18 0	..
1913,	1,604	5 7 0	8 11 4	−3 4 4	..
1914,	1,083	3 12 2	7 16 0	−4 3 10	..
Final Average, - -	1,331	4 8 9	8 4 2	−3 15 5	..

In only one case, namely at Holmes Farm, in 1914, the return in milk increase was almost of sufficient value to pay for the cost of the food consumed. At Mains of Twynholm in 1913 the value of the milk increase also was such as to nearly counterbalance the cost of the cake. On the other hand, the farm of Boghead has shown each year a large deficit against the feeding. As already explained, the figures obtained at Boghead in 1913, and the Crichton Royal in 1914, are less reliable.

The method of stating the figures in the above table is not, perhaps, suitable for general reference. For convenience, therefore, it has been thought worth while to express the final average in terms of *the result for one cow for the 12 weeks, as follows:—*

Total Increase of Milk for One Cow.		Cost of Food for	
Weight in lbs.	Money Value.	Producing Increase.	Deficit.
177	£0 11 9	£1 1 10	£0 10 1

The average result, where the milk yield only is concerned, shows a loss of about 10s. per cow from the addition of concentrated foods during the 12 weeks' grazing. From this sum, however, there must be deducted (*a*) the manurial value of the cakes, and (*b*) the value of improvement, if any, in the general condition and health of the animal which may result from the extra feeding.

In respect to the Manurial Value of the Cakes, the average figures worked out on the basis of Hall and Voelcker's tables amount to £2 15s. 6d. for the cake consumed at each centre, and to 7s. 4d. when expressed in terms of cake consumed by one cow. When these sums are deducted respectively from the £3 15s. 4d. in Table XI and from the 10s., the difference against the cost of the feeding is reduced to £1 per lot, or to 2s. 6d. per cow. As to whether the usual basis of valuation of the manure residues supplies the correct figure for the

case in point is a question with which the writer is not concerned at present.

In respect to the Value to be placed on the Improved Condition of the Animal, where such exists, as a result of the extra feeding, the exact amount is a difficult figure to arrive at. Very few definite data are available on this point. However, the fact that the efficiency of the food, in its effect on milk production, show on the average such marked increases with the advance in the season, seems to indicate that the requirements of the cow were not being completely satisfied by the pasturage. To what extent, if any, the general health and vitality of the cow might suffer under the condition in question there are no direct data to show, but the scarcity of grass commences at a time when the nights are getting colder and the demands of gestation are increasing. On page 34 it was remarked that no visible difference in the condition of the animals of the two lots was discernible at the end of the experiment. However, after deducting the value of the milk increase and of the manure residues from the cost of the cake consumed, a difference of one half-crown remains to square the cost of the extra feeding. Although, according to the method of computation followed, one half-crown is sufficient to make good any loss, the experiment does not show that there was any improvement in the general condition of the animal brought about by the extra feeding. Undoubtedly, cows heavy with calf will benefit materially from a more liberal supply of nourishing food at such a time, and it is quite possible that very favourable results will be forthcoming, both on the progeny and on the subsequent lactations.

As to the advisability of carrying out in practice the scheme of feeding followed in the present experiment, or as to whether the extra feeding should be extended to the whole of the grazing season, everything depends upon local conditions in respect to pasturage and the acreage available, but of course the question of the utilisation of the milk, whether for cheese-making or for selling purposes, also makes a difference. The

final decision as to the time and extent of the extra feeding will, in any case, remain to be decided in accordance with the requirements of the local circumstances.

The Fourth Month of the Experiment.

In the scheme of the experiment, on page 18, it is pointed out that the milk of the cows at each centre was weighed daily for several weeks after the feeding had stopped, and when both lots of cows were being treated alike. The result is given in Table XII, page 42.

TABLE XII.

The Yields of Milk for the Fourth Month of the Experiment.

Name of Centre.	Total Yield of Milk in Lbs. during Period from—		Increased Yield of Milk of Lot B over Lot A for the same Period.	
	Lot A.	Lot B.	In Lbs.	In Percentages.
1912.	Oct. 9th to Nov. 17th.			
Holmes Farm, - -	3,593	5,221	1,628	45
Crichton Royal, - -	3,073	3,660	587	19
Boghead, - - -	4,874	5,154	280	6
Laigh Grange,* - -	1,084	1,424	340	31
Average, - - -	**3,156**	**3,865**	**709**	**22**
1913.	Oct. 8th to Nov. 24th.			
Holmes Farm, - -	4,517	5,870	1,353	30
Crichton Royal, - -	3,459	4,436	977	28
Mains of Twynholm, -	3,399	3,809	410	12
Glassock, - - -	5,086	5,558	472	9
Average, - - -	**4,115**	**4,918**	**803**	**20**
1914.	Oct. 11th to Nov. 21st.			
Holmes Farm, - -	2,552	3,649	1,097	43
Crichton Royal, - -	2,856	2,982	126	4
Boghead, - - -	4,920	5,242	322	7
Mains of Twynholm, -	2,844	3,120	276	10
Glassock, - - -	4,503	4,844	341	8
Auldtoun, - - -	2,654	3,597	943	36
Average, - - -	**3,388**	**3,906**	**518**	**15**
Average for the three Years,				
1912,	**3,156**	**3,865**	**709**	**22**
1913,	**4,115**	**4,918**	**803**	**20**
1914,	**3,388**	**3,906**	**518**	**15**
Final Average, -	**3,553**	**4,230**	**677**	**19**

* For one fortnight.

The table shows that the cows which had been receiving the extra feeding during the summer still retained a marked advantage in the milk yield, but the interesting fact is that the increase for the fourth month is not maintained at the same progressive rate as that of the three previous months, as shown in the following figures :—

	Months.			
	1st.	2nd.	3rd.	4th.
Percentage increase calculated upon each month's yield, ...	4·6	8·3	15·4	19·0
Percentage monthly increase calculated upon the total milk production, ...	1·76	2·46	3·60	3·62

The falling off in the rate of increase for the fourth month must be attributed to the larger yield of milk of the cows in Lot A from the more liberal feeding, notwithstanding the fact that many of the cows were nearly dry.

In Table XIII the figures for both of the periods of the experiment have been added together.

TABLE XIII.

The Total Results for the Four Months of the Experiment.

Name of Centre.	Total Yield of Milk in Lbs. during Period from—		Increased Yield of Milk of Lot B over Lot A for the same Period.	
	Lot A.	Lot B.	In Lbs.	In Percentages.
1912.	July 15th to Nov. 17th.			
Holmes Farm, - -	20,038	23,606	3,568	17·8
Crichton Royal, -	16,486	17,991	1,505	9·1
Boghead, - - -	22,892	23,899	1,007	4·4
Laigh Grange, - -	14,616	16,602	1,996	13·6
Average, - - -	**18,508**	**20,524**	**2,016**	**10·9**
1913.	July 19th to Nov. 24th.			
Holmes Farm, - -	20,876	24,400	3,524	16·9
Crichton Royal, -	17,660	20,350	2,690	15·2
Mains of Twynholm, -	18,504	21,048	2,544	13·7
Glassock, - - -	24,045	26,516	2,471	10·3
Average, - - -	**20,271**	**23,078**	**2,807**	**13·8**
1914.	July 19th to Nov. 21st.			
Holmes Farm. - -	13,480	16,847	3,367	25·0
Crichton Royal, -	12,718	12,816	98	0·8
Boghead, - -	22,752	23,483	731	3·2
Mains of Twynholm, -	18,826	21,262	2,436	12·9
Glassock, - - -	22,586	23,788	1,202	5·3
Auldtoun, - - -	13,262	15,004	1,742	13·1
Average, - - -	**17,271**	**18,867**	**1,596**	**9·2**
Average for each of the Three Years.				
1912,	18,508	20,525	2,016	10·9
1913,	20,271	23,078	2,807	13·8
1914,	17,271	18,867	1,596	9·2
Final Average,	**18,683**	**20,823**	**2,140**	**11·5**

The effect of the fourth month's figures has been to raise the average total increase of milk from 8·7 to 11·5 per cent., that is a further increase of 3 per cent. of the total milk produced. The addition of the 3 per cent. provides a clear profit—a little over £1 5s. per lot, or of 3s. per cow—for the whole experiment.

SUMMARY OF RESULTS.

The concentrated food used for supplementing the pasturage consisted of a mixture in equal proportions of decorticated cotton cake and soya bean cake; commencing about the middle of July, two pounds of the mixture were given daily to each cow for the first month of the experiment, and four pounds daily for the succeeding two months. There were fifteen centres at which the experiment was carried out, and the total number of cows employed was 224.

The average effect on the milk yield of supplying the additional food to cows on pasture was to produce an increase per cow of a little under one gallon of milk a week for the first month, a little less than one and a-quarter gallons a week for the second month, and nearly two gallons a week for the third month of the experiment. These increases when calculated as percentages of the yield of milk for the month amounted to about 4·5 per cent., 8·5 per cent., and 15·5 per cent. respectively for each of the three months.

The average total increase obtained during the three months amounted to between 8 and 9 per cent. of the milk production for that period. Of this amount, about 2 per cent. was obtained in the first month, 3 per cent. in the second month, and 4 per cent. in the third month of the experiment.

The heavier milking cows seemed, on the whole, to be more responsive to the extra feeding, though the evidence is not very clear when the results at individual centres are considered.

The fall in the milk yield due to the advance in lactation and gestation was slower in the case of the cows receiving the extra food, and in consequence the period of lactation of the cows in question was lengthened to an appreciable extent

compared with that of the cows receiving pasturage only. The difference in the rate of fall of the milk yield in the two lots of cows accounted for the increases obtained.

The progressive return in milk yield produced by the concentrated foods in the latter part of the grazing season indicates clearly a falling off in the supply and nutritive value of the pasturage, or, in other words, a deterioration of its capacity for milk production. The increases, moreover, were achieved when most of the cows were well advanced in their period of lactation. Further, with the approach of autumn, the advent of colder nights and lower day temperatures, and likewise the increasing demands of gestation also contributed to the result.

No advantage, so far as any improvement in the fat content of the milk is concerned, appears to result from the feeding of the cakes, when compared with the fat content of the milk of the cows receiving no additional food. In fact, owing to the more rapid advance in lactation, the rise in the percentage of milk fat towards the end of the experiment was greater in the case of the cows receiving grass only. (See also result of experiment on the yield and composition of milk during lactation, page 56.

The results obtained at the individual centres, as would be expected, show considerable variation in the relative response in milk yield to the extra feeding (see Tables IV and V). The cause of variation is mainly due to a difference in the quality and supply of the pasturage, and to a difference in the relative number of stock which the pasture is made to carry. The grazing value of the pasturage at any one centre is determined by such local conditions as the type of soil, its elevation and exposure, the botanical nature of the herbage, the management of the pasture, and by the relative effect of weather conditions.

The weather during the three years of the experiment (1912-1914) was somewhat exceptional, inasmuch as the total rainfall each year was below the mean, and the deficiency occurred mostly in the late summer and autumn months. It is probable, therefore, that the weather conditions prevailing during the period of the experiment gave rise to effects on the pasture which would be more favourable to the results from the feeding

of the cake compared with other years. A distinct scarcity of grass was recorded at several centres where the response was the greatest.

The value of the milk increases, when calculated at 8d. per gallon, amounts on an average to about 11s. 9d. per cow, and the average cost of the extra food consumed per cow was £1 1s. 10d. This leaves a deficit of about 10s. per cow against the cost of the feeding for the three months. However, after deducting the manurial value of the cakes, calculated upon the basis of Hall and Voelcker's tables, and using pre-war prices, and which amounted to 7s. 4d., a difference of about one half-crown is left against the cost of the feeding, without taking into account the value of the enhanced condition, if any, of the cow. The return in money value of the milk increases obtained at each centre is given in Table XI, page 38.

The condition of the cow, in so far as it is affected by the extra feeding, is a very important factor, and must be taken into consideration in making up a profit and loss account. In the opinion of each of the experimenters, the condition of the cows receiving the concentrated foods did not show any visible improvement at the end of the experiment compared with that of the cows receiving pasturage only. It is reasonable, however, to assume that the milk increases obtained were produced largely at the expense of the extra food supply, and that the condition of the cow in consequence would not suffer. On the other hand, although no figures are available, it is possible that the advantage in the general health and vitality of the cows compared with that of the cows receiving no cake was such as to influence very favourably both the progeny and the subsequent lactations. In any case, one half-crown would, under the circumstances, seem a low estimate for any improved health condition.

As to whether the additional food supplied in the present experiment was adequate, or whether the application should have been extended throughout the whole of the grazing season, the results do not definitely show. Nor does it follow that other food would give the same return. The time and extent of the feeding may be open to modification in accordance with the requirements of local conditions.

The cows which had received pasturage only during the summer grazing responded better to the feeding indoors compared with the cows which had received extra feeding on the pastures. This result was shown in the milk yields recorded after the experiment proper had finished.

The writer desires to take this opportunity of expressing, on behalf of the Governors of the West of Scotland Agricultural College, their great indebtedness to Mr. Will of the Crichton Farm, Mr. Robert Stevenson of Boghead Farm, Mr. James Smith of Mains of Twynholm, Mr. James Wyllie of Glassock Farm, Mr. M'Harg of Laigh Grange, and to Mr. Gavin Hamilton, Lesmahagow, for placing at the disposal of the College suitable cows for the purpose of this experiment, also for the great personal interest and care which each of the experimenters has shown in the conduct and supervision of the experiment. His special thanks are also due to Mr. Peter Caldwell and Miss Dawson, upon whom has fallen the analytical work and the tabulation of the results; to Mr. Lindsay Robb, Holmes Farm, and Mr. D. G. O'Brien, M.A., B.Sc., formerly of the Chemical Department of the College.

THE YIELD AND COMPOSITION OF COWS' MILK DURING LACTATION.

The first milk after parturition, namely, the colostrum or "biestings," offers in composition and properties a marked contrast to normal milk, a number of days elapsing before a normal secretion of milk is reached. For some weeks after calving the yield of milk, as a rule, gradually rises; afterwards a more or less regular fall sets in until the cow goes "dry." The length of time in which a cow remains in milk is shortened by gestation, especially in its later stages. In absence of gestation cows are known to remain in milk for a considerable length of time. The period of lactation will therefore depend to a great extent upon the time that elapses between the date of calving and the date of last service.

Changes in the composition of milk also occur as the lactation progresses, the outstanding feature, perhaps, being the more or less regular rise in the percentage of milk-fat. Of other changes which occur, the broad outlines have already been worked out, and the general results are within the knowledge and experience of most dairymen. In the present preliminary contribution the effects of individuality on the changes in the yield and composition of milk during lactation has been traced out in the case of three cows. The work which is still in progress was undertaken with the object of furnishing data required for subsequent investigations.

The three cows available for the experiment were treated alike throughout the period during which the tests were made. The first samples of milk were taken in the middle of April, 1915; monthly sampling was continued until the cows were dry. A sample consisted of proportionate parts of the morning and evening milk of each cow taken on three consecutive days. The specific gravity, total solids, and percentages of fat and of

nitrogen were determined in each day's milk, and the mean of the three determinations was taken as the final figure. In order to obtain sufficient fat for examination, the cream from a portion of each day's sample of milk was separated and added together, and afterwards made into butter. For this purpose the cream was ripened, diluted with water to the requisite consistency, and churned in a small glass churn. The butter granules were washed thoroughly with water on muslin, afterwards melted and filtered, and the filtered fat was used for examination.

Records of the feeding throughout the experiment were kept. In the first week of April the daily ration for each cow consisted of—

4 lbs. of a mixture of bean meal and bruised oats.
2 lbs. soya cake.
30 lbs. mangels.
7 lbs. hay.
20 lbs. oat straw.

The mangels were finished on the 15th of the month, and the straw on the 20th. More hay was then given three times daily. About the 1st of May the cows were put out to grass in the daytime, and they were given 2 lbs. of a mixture of bean meal and bruised oats morning and evening. By the 16th of May the cows remained out overnight on the pasture. From this date each cow received 2 lbs. of the above mixture per day; afterwards, as the grass became plentiful, the additional foods were stopped.

From the 21st of August to the 6th September the cows were put on to clover aftermath. From the 6th of September to the 25th October they were put on to a timothy meadow, and they were given from 2 to 4 lbs. daily of the above mixture of meals. From the 25th October the cows were lying in, and the daily ration for each cow was—

4 lbs. crushed oats and beans.
30 lbs. turnips.
7 lbs. hay.
13 lbs. oat straw.

On the 16th November the ration was—

4 lbs. crushed oats and beans.
2 lbs. earthnut cake.
30 lbs. turnips.
7 lbs. hay.
13 lbs. oat straw.

This ration was continued much the same until the end of the experiment.

Particulars of each Cow.—

Cow No. 7, age 5. — Date of last calving (3rd calf), 26th March, 1915; date of last service, 21st July.

1914 milk yield, 858 gals. Average fat content, 3·9 °/₀. Duration of lactation, 55 weeks.

1915 milk yield, 855 gals. Average fat content, 4·04 °/₀. Duration of lactation, 49 weeks.

Cow No. 17, age about 10.—Date of last calving (8th calf), 2nd April, 1915; date of last service, 13th July.

1914 milk yield, 713 gals. Average fat content, 3·6 °/₀. Lactation, 35 weeks.

1915 milk yield, 786 gals. Average fat content, 3·5 °/₀. Lactation, 39 weeks.

Cow No. 6, age 5.—Date of last calving (3rd calf), March 13th, 1915; date of last service, 19th July.

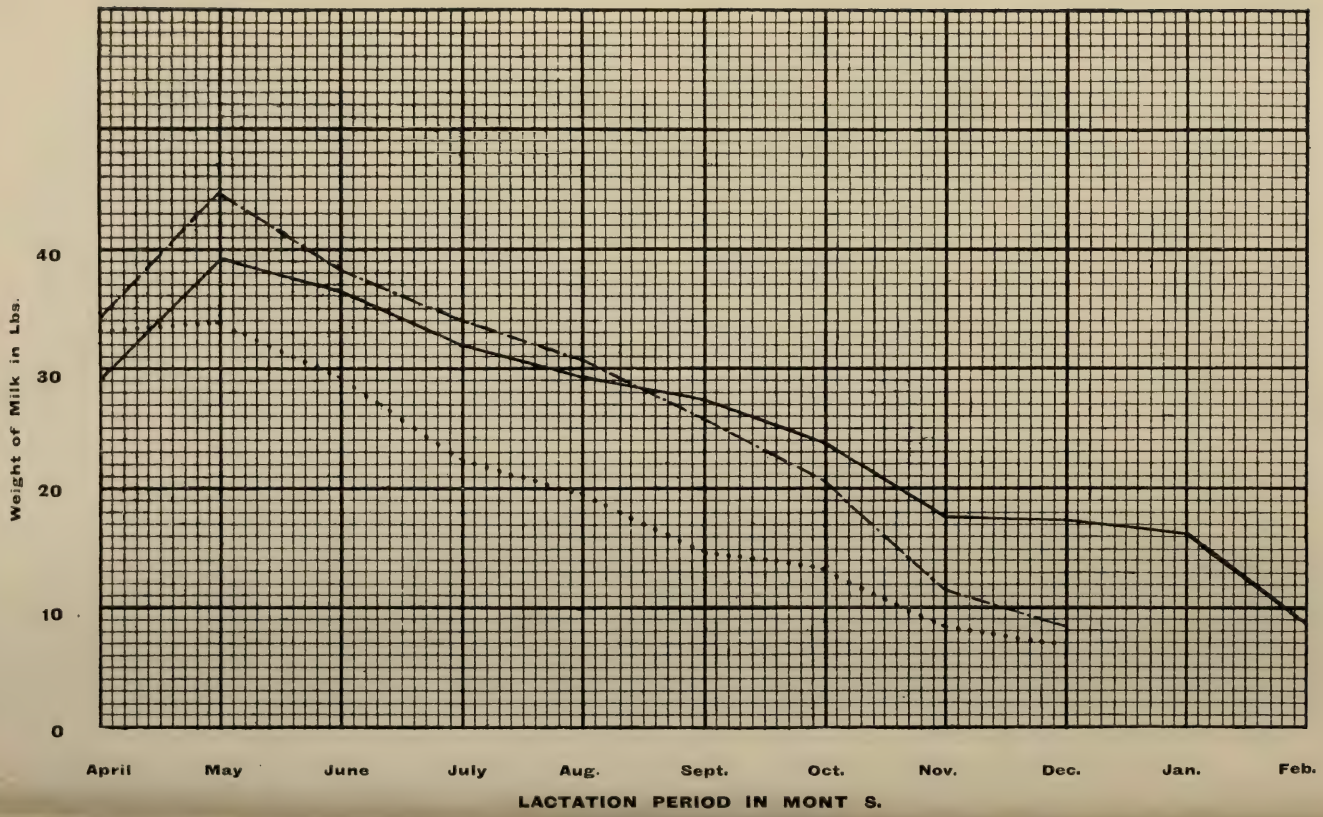
1914 milk yield, 596 gals. Average fat content, 3·7 °/₀. Lactation, 43 weeks.

1915 milk yield, 606 gals. Average fat content, 3·6 °/₀. Lactation, 42 weeks.

In order to compare the influence of lactation and of gestation on the milk of the three cows, it was necessary to carry out certain tests. The tests were limited to a few specific points, and the results obtained are given under the following headings :—

The Milk Yield.—The average monthly yield of milk from each cow during lactation is shown in Graph I, page 52.

GRAPH I.


Weight of Milk in Lbs.
40
30
20
10
0
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
LACTATION PERIOD IN MONT S.
Cow No. 7

Graph I.

The rise in the month of May, in the case of cows Nos. 7 and 17, is a little exaggerated, owing to the effect on milk secretion of the change from indoor feeding to pasturage; but the interesting feature is the comparative immunity of cow No. 6 to the effect of this change. After the second month a regular fall sets in until the cows go dry. The rate of fall is much the same for each of the cows. The more rapid fall in the month of November may be influenced by the change back again from outdoor to indoor feeding. In normal lactations the fall, as a rule, is more rapid from about the eighth month. In the case of cow No. 7, an unusually good milker, the effect of gestation on milk secretion is not so pronounced, and, although the date of last service was much the same in each case, this cow remained two months longer in milk than the other two cows.

Other figures given in Table I, showing the general effects of the progress of lactation on the milk yield of cows calving in different months in the spring, are more representative, as they include the data from a large number of cows. The data for the figures in this and the following table were abstracted from the Scottish Milk Record Society's books in 1912, through the courtesy of the Milk Record Committee.

TABLE I.

Month of Calving.	Number of Cows.	Average Lactation in Weeks.	Average Yield of Milk per Cow in Lbs. Daily.									
			Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.
January,	54	39·8	30·1	28·3	26·4	27·4	25·5	26·4	19·7	15·3	9·9	8·3
February,	328	37·0	30·1	32·3	31·5	31·8	29·7	26·4	22·2	17·1	12·4	9·5
March,	298	33·8	...	31·7	33·3	34·2	30·0	27·3	23·3	17·4	12·5	9·5
April,	137	30·9	...	...	29·8	35·5	31·9	28·0	24·1	18·6	12·8	9·6

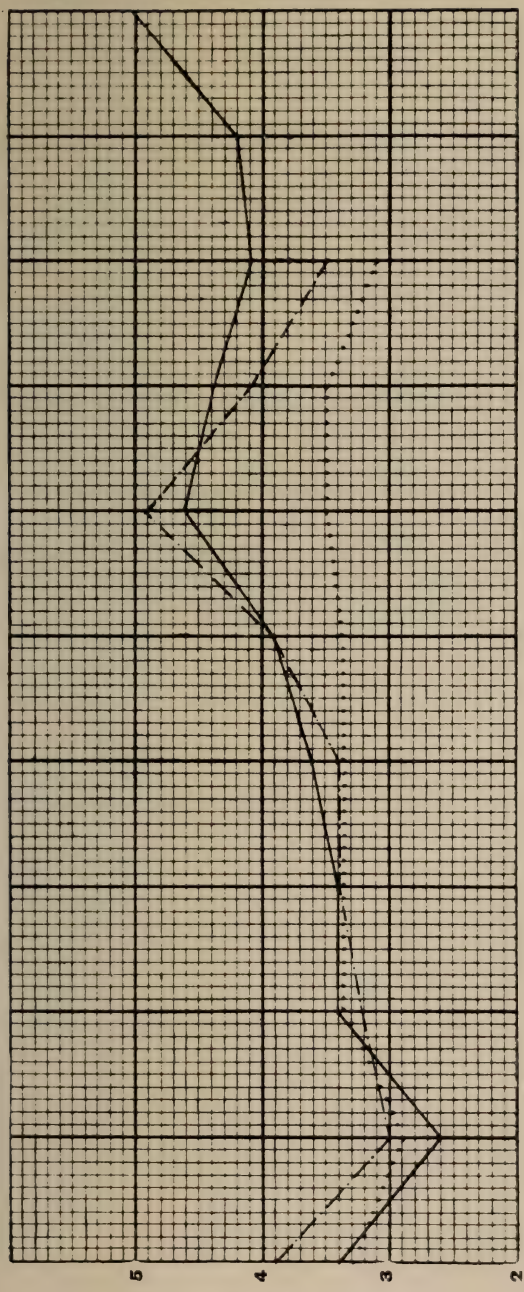
TABLE II.

Lactation. Months.	Average Daily Yield of Milk per Cow in Lbs.	
	Cows Calving in the Months of February and March.	Cows Calving in the Months of October and November.
1st Month, - -	Mar., 28·1	Oct., 34·0
2nd ,, - -	39·5	41·0
3rd ,, - -	42·5	38·1
4th ,, - -	41·3	31·4
5th ,, - -	37·1	31·1
6th ,, - -	31·0	26·7
7th ,, - -	23·2	28·2
8th ,, - -	17·2	27·3
9th ,, - -	11·2	22·0
10th ,, - -	6·6	13·4
11th ,, - -	...	6·9
Average number of weeks' Lactation, -	38·3	41 7
Average Age of Cow, -	7·1	6·9
Number of Cows, -	85	85

The figures in the tables explain themselves. Attention, however, might be drawn to the influence of environment and nature of food on milk secretion, such as is shown in these figures by a change from indoor to outdoor feeding, or the reverse.

The Milk-Fat.—The variation in the milk-fat during lactation for the three cows is given in Graph II, page 55.

GRAPH II.


Percentage of Milk Fat.
5
4
3
2
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
LACTATION PERIOD IN MONTHS.
Cow No. 7
" No. 17
" No. 6

GRAPH II.

The normal variation has, like the milk yield, been modified to some extent by external influences. The turning of the cows out to pasture has caused a rapid drop in the percentage of fat in the month of May. Otherwise the curves show a gradual rise until towards the end of the lactation. The rapid rise in the fat content in the case of cows Nos. 7 and 17 for the month of October, followed by an equally rapid fall, again shows an interference with the normal lactation effects. In the month of October the cows were on timothy grass and the allowance of concentrated food was increased to about 4 lbs. daily. Cow No. 6 again exhibits a remarkable indifference to change. Although the milk yield of this cow showed a regular fall, the rise in the percentage of fat with advance in lactation was scarcely perceptible. The figures contained in Table V were abstracted from the Milk Record Society's book at the same time as those of Tables I and II.

TABLE V.

Month of Calving.	Number of Cows.	Average Percentage of Fat in Milk.									
		February.	March.	April.	May.	June.	July.	August.	September.	October.	November.
January, -	54	3·7	3·6	3·7	3·7	3·7	4·0	4·0	4·1	4·3	4·6
February,	328	3·7	3·5	3·4	3·6	3·6	3·7	3·8	4·0	4·3	4·6
March, -	298	...	3·6	3·4	3·5	3·5	3·7	3·8	4·1	4·4	4·5
April, -	137	...	...	3·6	3·4	3·5	3·6	3·7	4·0	4·5	4·5

Some physical and chemical properties of the fat were also examined.

The physical properties investigated were confined to an examination of the refraction index of the fat, the relative size of the fat globules, and the colour. It was intended to include the churnability of the cream, but, owing to the relatively small amount of cream available, the test was not a reliable one.

Measurement of the fat globules were made with a micrometer scale, and it was found that, although the relative size of the large and the small globules remained much the same, the proportion of the small to the large-sized globules in the fat increased appreciably towards the end of the lactation.

As regards the colour, the April sample was very pale compared with the rich yellow of the sample taken in the month of May. The rich yellow colour persisted, with varying shades, until about the month of November, from which time the samples became distinctly paler. In the case of cow No. 6 the samples began to pale much earlier. Exposure to light gradually bleaches the colour. When the fat was melted, which was done at as low a temperature as possible, and allowed to cool slowly, so that a partial separation of the solid and liquid fats occurred, the colour remained mostly in the liquid portion. The variation in the refractive index is given in Tables III and IV.

The chemical examination included an estimation of (1) the volatile fatty acids (*a*) soluble in water (Reichert-Meisel number), (*b*) insoluble in water (Polenske number); (2) the unsaturated fats (the iodine absorption figure). The results are given in Tables III and IV.

TABLE III.

Month.	Cow No. 7.				Cow No. 17.				Cow No. 6.			
	Reichert-Meisel Number.	Polenske Number.	Iodine Absorption.	Refractive Index at 35°C.	Reichert-Meisel Number.	Polenske Number.	Iodine Absorption.	Refractive Index at 35°C.	Reichert-Meisel Number	Polenske Number.	Iodine Absorption.	Refracti Index at 35°
			Per cent.				Per cent.				Per cent.	
April,	31·35	2·00	...	45·5	31·68	1·45	...	46·5	32·89	2·8	...	44·
May,	29·57	3·64	43·55	46·5	28·35	2·80	40·58	46·5	30·94	3·7	36·02	45
June,	30·77	3·10	35·10	45	32 84	2·65	36·10	45	28·13	2·6	36·97	46
July,	30·44	2·77	35·06	45	31·13	2·20	41·36	46	27·72	2·0	37·72	46
Aug.,	29·04	2·45	41·27	46	27·31	2·45	43·39	47	24·94	2·1	41 67	47
Sep.,	29·02	2·80	37·80	45	28·44	2·30	43·18	46	26·29	2·2	38·73	46
Oct.,	26·95	2·85	39·73	46	27·03	2·65	38·70	46	24·53	2·75	40·25	47
Nov.,	30·64	2·95	28·77	43	28·44	2·55	31·80	44·5	25·41	2·10	37·12	45
Dec.,	28·57	2·05	32·49	44·5	28·13	2·80	35·40	45·5	23·46	1·70	38·09	46
Jan.,	29·67	1·90	35·00	45	...	...	...	...	...	...	...	...
Feb.,	23·02	1·40	38·19	47	...	...	...	...	...	...	...	...

TABLE IV.

Average Results of the Three Cows.

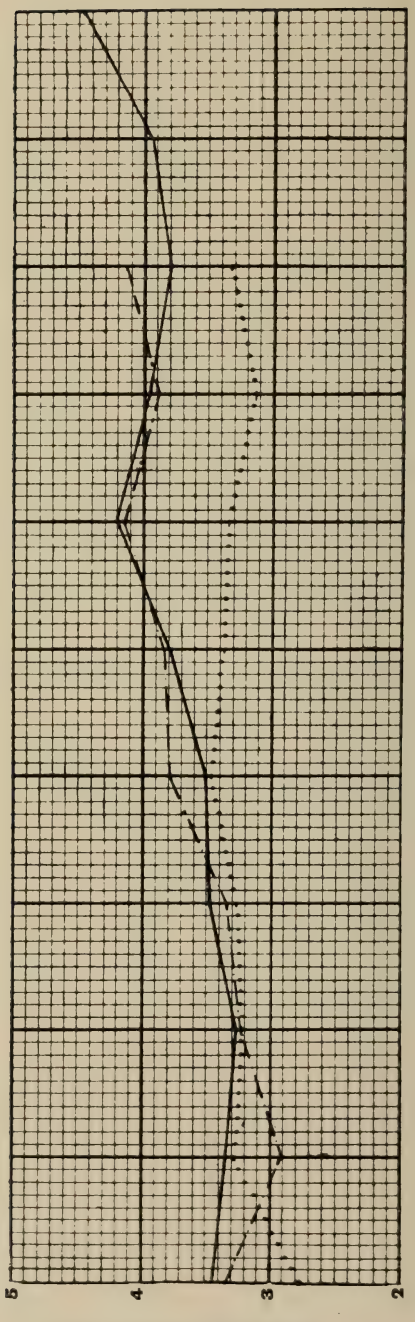
Month.	Reichert-Meisel Number.	Polenske Number.	Iodine Absorption.	Refractive Index at 35°C.
			Per cent.	
April, -	31·97	2·08	...	45·5
May, -	29·62	3·38	40·05	45·7
June, -	30·58	2·78	36·05	45·3
July, -	29·76	2·32	38·04	45·6
August, -	27·09	2·33	42·11	46·6
September,	27·91	2·40	39·90	45·6
October, -	26·17	2·75	39·56	46·3
November,	28·16	2·50	32·56	44·2
December,	26·72	2·18	35·32	45·5

Changes in the feeding of the cows, such as already referred to, and which caused either a depression or a rise in the fat content of the milk, have also reacted on the composition and character of the fat, apart from the normal effects of lactation. The sudden drop in the amount of volatile fatty acids for the months of May and October coincided with a marked alteration in the fat content of the milk for the two months. Otherwise the mean results show that the effect of lactation on the proportion of the volatile fatty acids in butter-fat is to produce a gradual falling off with the advance in lactation. According to the observations of previous workers, it was not expected that the change to pasturage from indoor feeding would at first depress the butyric acid content of the fat, a result obtained in the present experiment. The rapid fall in this component for the month of October is in agreement with other published observations. The colder nights and a falling off in the supply of pasturage were found to be the contributory causes. By the end of October the cows were kept indoors overnight.

The iodine absorption, which indicates the olein content of the fat, shows a more or less considerable rise, as a result of the feeding of the pasturage. These figures confirm the observations made on the degree of hardness of the butter-fat. Apart from the effects of the warm summer weather, the butter was, by comparison, softer in the summer months. The rapid drop in the month of November coincides with the change from outdoor to indoor feeding and a complete change of food. The refractive index, as would be expected, follows much the same order of variation as the iodine absorption. The olein content of the fat is very susceptible to change, dependant very largely upon the nature of the food supply.

The Milk Protein.—The variation in the milk protein in each of the cows' milk during lactation is given in Graph III, page 60.

GRAPH III.


Percentage of Total Protein.
5
4
3
2
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
LACTATION PERIOD IN MONTHS.
Cow No. 7
" No. 17
" No. 6

Graph III.

The curves follow much the same order of variation as the fat, and, like the fat, the milk protein gradually increases with advance in lactation. The general relationship between these two constituents is shown in the following figures :—

Lactation in Months.

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Fat, percentage,	3·5	2·8	3·3	3·4	3·5	3·8	4·3	4·0	3·5
Protein (total) percentage,	3·18	3·18	3·24	3·34	3·58	3·66	3·88	3·66	3·75

The connection, however, is seen to be much closer when the figures from a larger number of cows are compared.

No attempt was made to separate the milk protein into its casein, albumen, and globulin content, but other workers have shown that the proportion of albumen increases with the advance in lactation. The casein content of milk, which varies from about 77 to 82 per cent. of the total protein, is important, in that it provides, along with the fat, a basis of comparison for the cheese-producing capacity of milk.

Rennet tests with each sample of milk were carried out. The tests were always made at a temperature of 30° C., and with the same concentration of rennet. The milk was soured, and the time which the rennet took to act at different acidities was taken. The acidity of the whey was also taken immediately after renneting. The result is given in Table VI, page 62.

TABLE VI

Acidity of Milk in Terms of Lactic Acid.

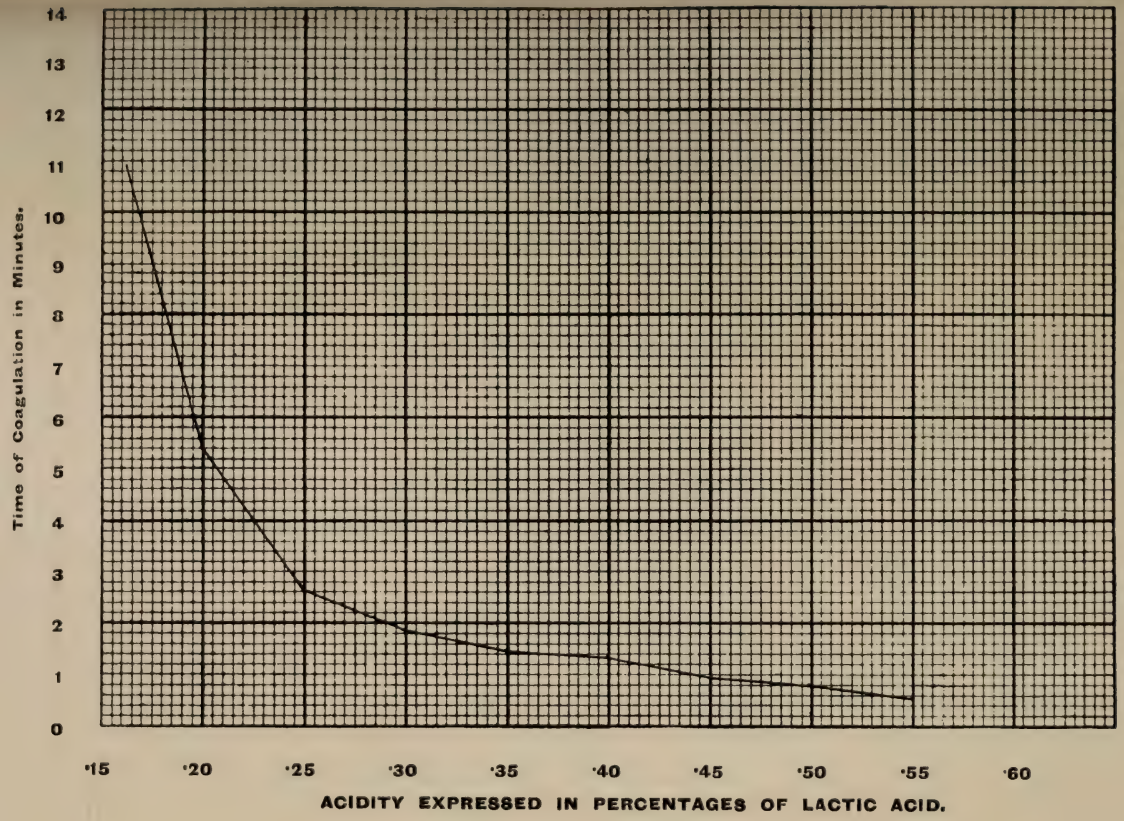
Just before Rennet Action.	Just after Rennet Action.	Percentage Decrease in acidity due to Rennet Action.
Per cent.	Per cent.	
·165	·101	38·8
·199	·130	34·7
·249	·166	33·3
·303	·205	32·3
·348	·237	31·9
·395	·277	29·8
·450	·314	30·2
·504	·355	29·6
·552	·386	30·1

The results of the rennet test obtained during the course of the lactation were somewhat contradictory, but the connection between the acidities and the rennet action, which may be of use in future work on the mechanism of the rennet change, is given in Graph IV, page 63.

Graph IV.

Some experiments of a preliminary nature, to show the influence on the rennet action of the addition of soluble lime salts, including acid phosphates, to milk, were carried out, and in the meantime it may be of interest to point out that the addition of the soluble lime salts hastened appreciably the rennet action, a result well known to many cheesemakers, whilst salts of sodium and potassium retarded it. The effect on the texture of the curd was also recorded.

GRAPH IV.


Time of Coagulation in Minutes.
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
·15
·20
·25
·30
·35
·40
·45
·50
·55
·60
ACIDITY EXPRESSED IN PERCENTAGES OF LACTIC ACID.

In a further experiment, carried out in the summer of 1912, to show what effect a supply of phosphate of lime, amounting to 4 ozs. daily to cows on pasture, would have on the rennet action, the result, so far as the rate of action of the rennet and the texture of the curd was concerned, did not seem to differ from that obtained when no phosphate was added to the food. It has already been established by several investigators that the addition of phosphates to the food of dairy cows does not produce any increase in the percentage of phosphate in the ash of milk.

Reaction of Fresh Milk.—A determination of the neutralising power of fresh milk using $\frac{N}{9}$ soda and phenol phthalein as indicator was made with each sample of milk during the lactation, and the result, for convenience, is expressed in terms of the percentage of lactic acid in Table VII.

TABLE VII.

Acidity of Milk Expressed in Percentages of Lactic Acid.

Month.	No. 7.	No. 17.	No. 6.	Average.
April, -	...	...	...	...
May, -	·14	·14	·18	·15
June, -	·13	·13	·15	·13
July, -	·13	·12	·14	·13
August, -	·15	·13	·14	·14
September,	·15	·13	·12	·13
October, -	·16	·12	·11	.13
November,	·14	·11	·10	·11
December,	·14	·10	·11	·11

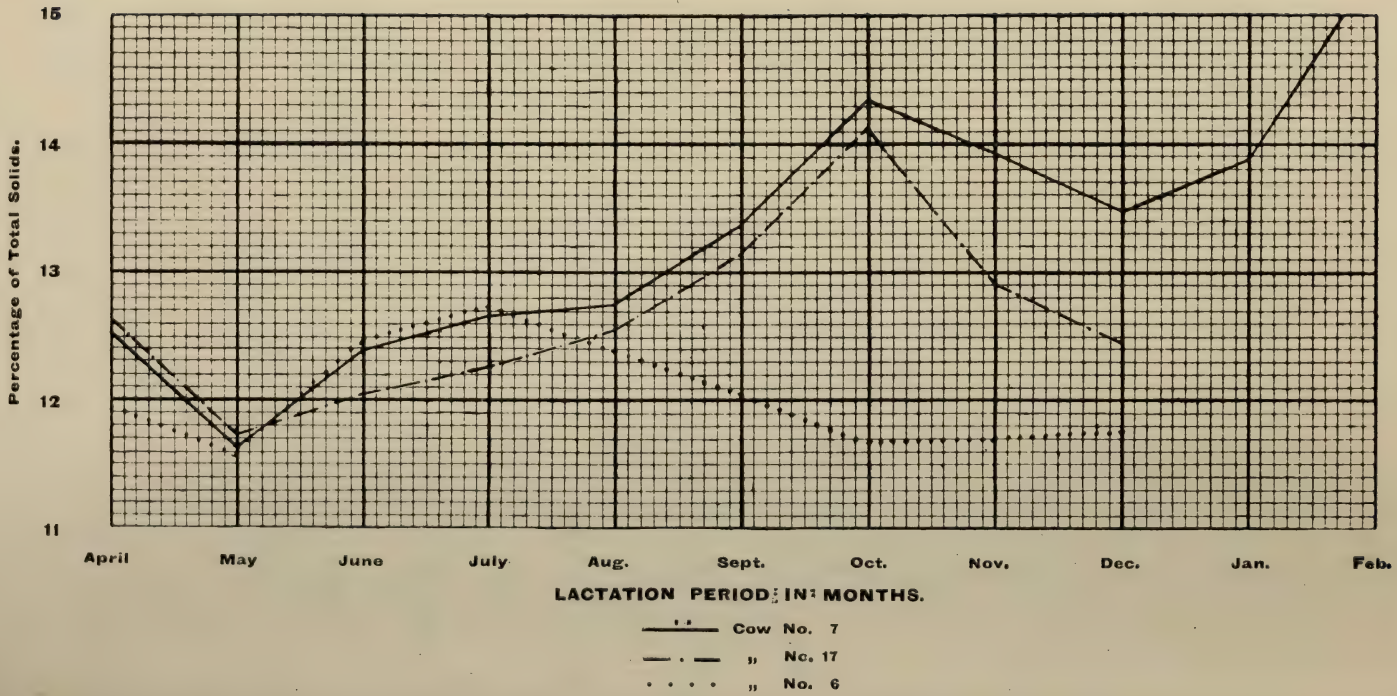
It would appear that the reaction of the fresh milk becomes less acid as the lactation advances. A discussion, however, on the cause of the peculiar reaction of freshly-drawn milk or on the cause of the alteration in the acidity during the rennet action, though of great interest, is not considered to be within the scope of the present paper. At the same time, it may be of interest to record the results of the acidity test with the milk obtained from cows receiving phosphates and salt respectively in their food. The results are contained in Table VIII.

TABLE VIII.

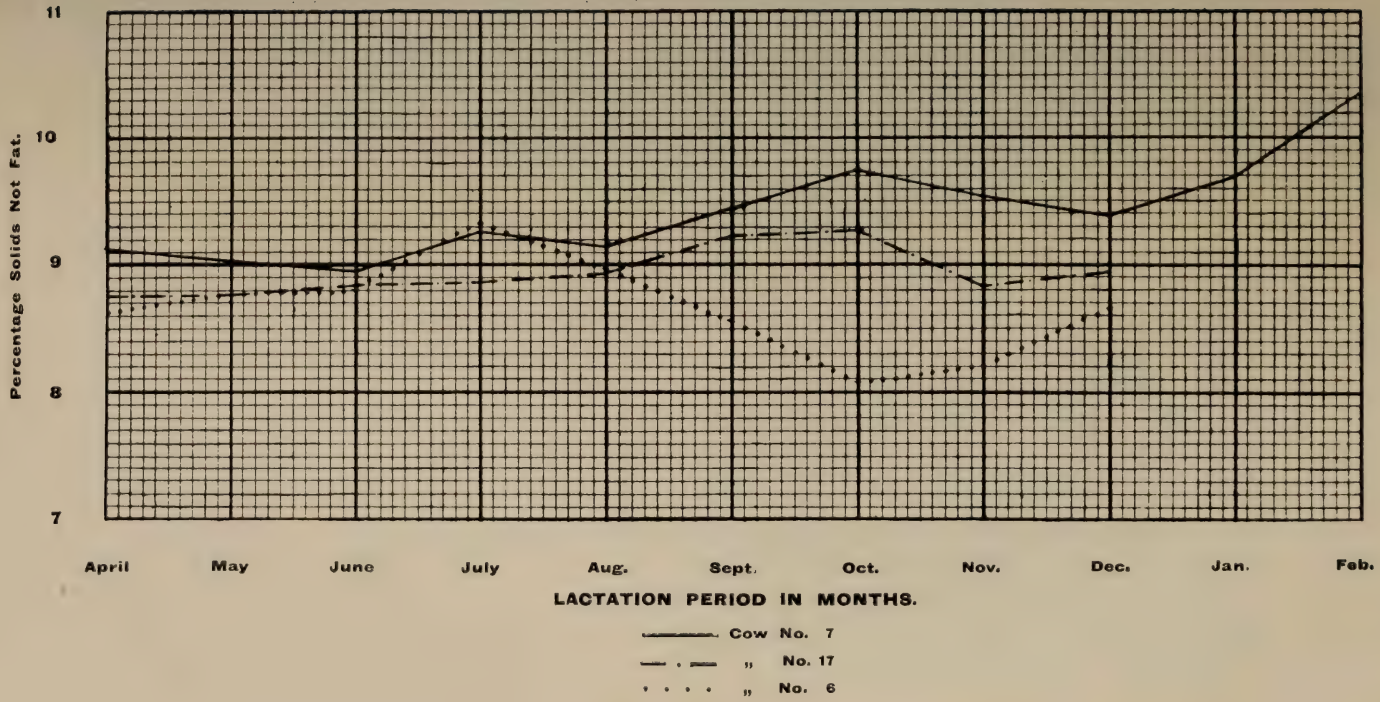
Date.	Number of Tests.	Cow No. 5.	Acidity. Per cent.	Cow No. 28.	Acidity. Per cent.
1913.					
July 6th,	9	Preliminary test,	·165	Preliminary test,	·130
„ 22nd,	10	Phosphate added,	·175	Salt added, -	·125
Aug. 10th,	8	Salt „	·170	Phosphate added,	·135
„ 24th,	9	Phosphate „	·175	Salt „	·130
Sept. 4th,	11	Salt „	·190	Phosphate „	·150
„ 20th,	16	Phosphate „	·200	Salt „	·150

The Total Solids and *the Solids not Fat* were determined in each sample of milk during the lactation, and the results are shown in the Graphs V and VI.

GRAPH V.


15
14
13
12
11
Percentage of Total Solids.
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
LACTATION PERIOD IN MONTHS.
Cow No. 7
„ No. 17
„ No. 6

Graph VI


11
10
9
8
7
Percentage Solids Not Fat.
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
LACTATION PERIOD IN MONTHS.
Cow No. 7
„ No. 17
„ No. 6

Graphs V and VI.

After what has been said in respect to the variation of the fat and protein content of the milk, it is unnecessary to enter into further explanation of the above curves, as they follow the expected order of variation. It may, however, be of interest to observe that, in the case of cow No. 7, the total solids amounted to over 15 per cent. towards the end of the lactation period. Had it been possible to eliminate all disturbing factors, and to measure only the effects of lactation on the composition of milk, the curves for total solids and its components would have shown a more gradual and regular variation throughout the lactation period. Apparently the depressing effect of the indoor feeding after the pasturage on the composition of the milk lasted several months. In the case of cow No. 7, the other two being dry, a recovery was made in the months of January and February, and the normal effect of lactation again showed itself.

The tests for each of the cows' milk are summarised in Tables IX to XII.

TABLE IX.

Cow No. 7.

Month.	Milk Yield in Lbs. daily.	Total Solids. Per cent.	Milk-Fat. Per cent.	Solids, not Fat. Per cent.	Protein (Total). $\%$ N × 6·38	Specific Gravity.
April,	29·2	12·53	3·4	9·13	3·45	1·0332
May,	39·2	11·63	2·6	9·03	3·36	1·0323
June,	36·4	12·35	3·4	8·95	3·28	1·0313
July,	32·0	12·65	3·4	9·25	3·47	1·0324
August,	29·2	12·75	3·6	9·15	3·50	1·0316
Sept.,	27·4	13·33	3·9	9·43	3·79	1·0321
Oct.,	23·7	14·33	4·6	9·73	4·18	1·0322
Nov.,	17·6	13·93	4·4	9·53	3·96	1·0330
Dec.,	17·4	13·49	4·1	9·39	3·80	1·0328
Jany.,	16·2	13·89	4·2	9·69	3·96	1·0335
Feby.,	8·9	15·32	5·0	10·32	4·48	1·0347

TABLE X.—Cow No. 17.

Month.	Milk Yield in Lbs. daily.	Total Solids. Per cent.	Milk-Fat. Per-cent.	Solids, not Fat. Per cent.	Protein (Total). $\%N \times 6{\cdot}38$	Specific Gravity.
April,	34·0	12·64	3·9	8·74	3·23	1·0339
May,	44·4	11·75	3·0	8·75	2·92	1·0311
June,	38·7	12·01	3·2	8·81	3·21	1·0311
July,	34·0	12·25	3·4	8·85	3·33	1·0305
August,	30·8	12·56	3·4	9·16	3·78	1·0318
Sept.,	25·9	13·11	3·9	9·21	3·83	1·0317
Oct.,	20·4	14·15	4·9	9·25	4·14	1·0307
Nov.,	11·7	12·92	4·1	8·82	3·90	1·0302
Dec.,	8·5	12·46	3·5	8·96	4·14	1·0298

TABLE XI.—Cow No. 6.

Month.	Milk Yield in Lbs. daily.	Total Solids. Per cent.	Milk-Fat. Per-cent.	Solids, not Fat. Per cent.	Protein (Total). $\%N \times 6{\cdot}38$	Specific Gravity.
April,	33 0	11·94	3·3	8·64	2·75	1·0318
May,	33·8	11·68	2·9	8·78	3·28	1·0322
June,	29·3	12·41	3·4	9·01	3 23	1·0314
July,	22·3	12·71	3·4	9·31	3·24	1·0318
Aug.,	19·9	12·37	3·4	8·97	3·47	1·0308
Sept.,	14·9	12·02	3·45	8·57	3·36	1·0295
Oct.,	13·2	11·68	3·5	8·18	3·34	1·0284
Nov.,	8·3	11·70	3·5	8·2	3·11	1·0268
Dec.,	6·7	11·75	3·1	8·65	3·31	1·0298

TABLE XII.

THE AVERAGE RESULTS FOR THE THREE COWS.

Month.	Milk Yield in Lbs. daily.	Total Solids. Per cent.	Milk-Fat. Per-cent.	Solids, not Fat. Per cent.	Protein (Total). $\%N \times 6{\cdot}38$	Specific Gravity.
April,	32·1	12·37	3·5	8·87	3·18	1·0329
May,	39·1	11·68	2·8	8·88	3·18	1·0318
June,	34·8	12·25	3·3	8·95	3·24	1·0312
July,	29·4	12·53	3·4	9·13	3·34	1·0315
August,	26·6	12·63	3·5	9·13	3·58	1·0314
Sept.,	22·7	12·82	3·8	9·02	3·66	1·0311
Oct.,	19·1	13·38	4·3	9·08	3·88	1·0304
Nov.,	12·5	12·85	4·0	8.85	3·66	1·0300
Dec.,	10·9	12·56	3·5	9·06	3·75	1·0308

SUMMARY OF RESULTS.

The three cows under experiment remained on pasture during the greater part of the period in which the tests were made. The effect of the advance in lactation on the milk yield followed much the same order of variation in the case of two of the cows, but differed greatly in the third.

The normal effect of lactation on the milk yield was to some extent modified by other influences, such as the change from indoor feeding to pasturage, or the reverse, the susceptibility to change being relatively greater with the same two cows named above. This difference in susceptibility was also noticeable throughout the other tests.

According to data taken from a number of milk records, the average effect of lactation on the milk yield of cows calving in the spring or in the autumn generally showed a rise for the first two months after calving, followed by a more or less regular fall until the cows go dry. The length of the lactation was longer in the latter compared with the former cows.

The variation in the fat content of the milk, apart from the normal effects due to advance in lactation, with two of the cows was influenced appreciably by change in environment and feeding, particularly noticeable in the months of May and November, although by the latter month both cows were well advanced in their lactations. With one cow the fat content of the milk showed little variation from the beginning to the end of the lactation period.

According to data taken from a number of milk records, the average effect of advance in lactation on the milk fat generally showed a fall in the second month after calving, followed by a gradual rise until the cows went dry.

The physical and chemical properties of the fat were also subject to change with advancing lactation. For example, the proportion of the smaller-sized fat globules increased with advance in lactation. The feeding of the pasturage had the effect of producing a softer butter; also, it produced a rich yellow colour in the butter, which persisted in varying shades until the indoor feeding was again resorted to. The yellow colour appeared to be in the liquid portion of the fat, and gradually bleached on exposure to light.

The butyric acid content of the fat showed, on the whole, a gradual fall, due to the advance in lactation. The colder weather in the month of October accentuated the fall.

The iodine absorption and the refractive index seemed to be affected more by the feeding of the cows than by the advance in lactation.

The total protein content of the milk followed much the same order of variation as the fat.

The reaction of fresh milk appeared to become less acid with advance in the lactation.

The total solids were the lowest in the month of May, and in the case of two cows they gradually increased until the month of October. With the third cow the highest percentage reached was in the month of July, after which a gradual fall set in. At the end of the lactation the amount of total solids in the milk of one cow reached 15·3 per cent, while in the case of the other two cows it was lower than at the beginning of the lactation. The change back from pasturage to indoor feeding affected the amount of total solids differently for the three cows.

The writer wishes to acknowledge his indebtedness to Mr. Peter Caldwell, who carried out most of the analytical work involved in this experiment, and also to Miss Dawson, who assisted in this work.

THE CHANGES IN THE COMPOSITION OF CHEDDAR CHEESE DURING THE PROCESS OF RIPENING.

In the summer of 1914, when pure cultures of *Streptococcus lacticus* and of *Bacillus bulgaricus* (Metchnicoff) were being prepared in the Bacteriological Department of the College for use as "starters" in the making of cheddar cheese, the time seemed opportune for commencing a systematic investigation into certain problems in connection with the chemistry of cheese-making. The particular points upon which it is intended to eventually concentrate attention are those which give rise to texture and flavour in cheese, properties which, to a large extent, decide its market value. Owing, however, to the war, it has not been possible to carry out more than a few preliminary tests, the results of which provide the material for this short report.

Alteration in the composition of milk commences with the action of the starter on the milk sugar, the lactic acid produced reacts with the caseinogen and lime compounds of the milk, and sets up a condition more favourable for the action of the rennet. The formation of the curd by the rennet marks a further stage in a complex series of changes. Subsequently, in the cheese vat, during the process of cooking and cheddaring of the curd, other actions develop which have a decisive influence upon the texture and flavour ultimately acquired by the ripe cheese.

Each stage is determined by the completion up to a certain point of a definite chemical action or set of actions, brought about by the agency of micro-organisms and enzymes. Decomposition products are formed which have a decided effect upon the surrounding medium. The identification and isolation of these compounds, the nature of the changes producing them, and their function in cheese-making, has already been the subject of a considerable amount of work by chemists, but much remains to be accomplished. For example, the rennet

action is still a matter of considerable obscurity; the "acidity" of milk and whey and its true significance rests upon uncertain data, although the recent use of potassium oxalate in arriving at the true acidity is an advance; the factors which influence the condition and texture of the curd await further systematic research; the substances which contribute to the flavour in cheese and the exact conditions under which they are formed are little understood—besides other lines of inquiry. The complete elucidation of these changes and their correlation with all the known factors is, therefore, a matter of fundamental importance in cheese-making.

The practical cheese-maker with the aid of certain simple tests, and by the appearance of certain features in the curd, has learned by experience to judge when each change has gone far enough; and by adopting certain methods, founded upon a scientific basis, he knows how best he can keep the changes more or less within his control. In the production of the different varieties of cheese he knows exactly what modifications in the process must be introduced in order to attain the particular features desired.

As already indicated, the preparation and treatment to which the curd is subjected in the making of the green cheese profoundly influence the changes which take place and the rate at which they progress in the subsequent process of ripening, a process which is mainly responsible for the production of the features which distinguish and characterise the marketable cheese.

In the present experiment the few tests which were carried out were confined to certain changes which take place during the ripening process. For the purpose of the experiment a cheddar cheese, in the making of which a pure culture of *Streptococcus lacticus* was used as starter, was kindly placed at the disposal of the Chemistry Department by Mr. William Stevenson, B.Sc., formerly Lecturer in Bacteriology and Dairying in the College. The milk was renneted at an acidity of ·25 per cent., calculated in terms of lactic acid. The acidity of the whey when run off from the curd was ·26 per cent., and when draining from the cheese-press was 1·08 per cent. The

cheese was stored in the curing-room from June 25th, 1914, to March 23rd, 1915. Samples were taken monthly for analysis. Each sample consisted of five cores, taken with a cheese-pale, the holes afterwards being filled up with warm paraffin wax. The cores were put through a fine sieve with round holes 1 cm. in diameter, and the fine material was used at once for analysis. The results of the analyses are given under the following headings :—

The Nitrogen Compounds.—The total nitrogen, the nitrogen compounds soluble in water, and the nitrogen compounds in the form of ammonium salts were each determined, and the results are given in Table I. No attempt was made to further separate the decomposition products of the paracasein into the proteins soluble and insoluble in brine, into paranuclein, proteoses, peptones, and amino compounds.

TABLE I.

	Month in which Sample was taken.								
	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Percentages in Cheese.									
Nitrogen (total), -	4·05	4·07	4·07	4·10	4·18	4·24	4·25	4·30	4·19
Water Soluble Compounds of Nitrogen, -	0·109	0·582	0·947	1·12	1·33	1·38	1·46	1·55	1·55
Nitrogen as Ammonium Compounds, - -	·014	·031	·047	·056	·066	·071	·075	·078	·094
Expressed in Percentages of Total Nitrogen.									
Water Soluble Compounds of Nitrogen, -	2·7	14·3	23·2	27·3	31·8	32·5	34·3	36·0	37·0
Nitrogen as Ammonium Compounds, - -	0·34	0·76	1·1	1·4	1·6	1·7	1·76	1·8	2·2

The total nitrogen shows a gradual increase from the beginning to the end of the ripening period. This is due to a slow and continuous loss of water (see Table II). The proportion of water soluble compounds amounted to nearly 3 per

cent. of the total nitrogen at the first sampling—that is in the green cheese. During the first three months the amount increased rapidly to over 23 per cent., after which the rate of increase gradually slowed down. By the ninth month the total amounted to 37 per cent. This conversion of the insoluble paracasein into water soluble compounds coincides with the transformation of the green cheese from an indigestible to a more easily digestible condition. At the same time other features develop. At the commencement the green cheese is practically tasteless, but it soon takes on the characteristic cheesy flavour, a property arising from the presence of certain specific chemical compounds. Besides, the more or less tough and elastic curd changes into a soft and pliable form, a result caused by the alteration in the physical condition of the protein matter. The small but persistent rise in the amount of the ammonium compounds is also a change of some significance.

The conversion of the insoluble paracasein into water soluble compounds is the most characteristic change in the process of cheese ripening, and the extent to which the change has taken place is taken as being a measure of the stage which the ripening process has reached. A number of the compounds formed during the process of ripening have already been isolated by other investigators.

The Sugar and Acidity.—Estimations of the sugar were made, but the figures were not considered to be very reliable, and for this reason the actual amounts obtained in the second and third sampling are not given (see Table II). After that period no trace of sugar was found. The disappearance of the sugar and its conversion into lactic acid and other derivatives appears not to be complete in this case until the end of the third month is reached. However, further experiments on these points are in progress.

The acidity was estimated by titration with $\frac{N}{9}$ soda using phenol phthalein as indicator, and the result is given in Table II. For convenience the result is expressed in terms of lactic acid. The acidity, however, largely represents that due

to acid salts, although no estimation of their amount was made in this case. It is, nevertheless, an important factor connected with the physical condition of the protein, or, in other words, with the texture of the cheese. It is also a factor governing the action of the enzymes.

The moisture amounted to 35·6 per cent. in the green cheese, and slowly decreased with the age of the cheese, until at the end of the experiment it amounted to 32·1 per cent. The loss of moisture produced a corresponding increase in the amount of protein and fat. The *ash* content included the added salt. *The weight of the cheese* at the end of the first month's experiment was 53 lbs. 15 ozs. The weight slowly decreased, until at the end of the experiment the weight was 50 lbs., a loss of about 7 per cent.

The cheese at the end of the experiment had a very palatable and somewhat sharp taste, and its texture was good.

TABLE II.

	Month in which Sample was taken.									
	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Ma
Moisture, - - -	35·68	35·25	34·62	34·00	33·70	32·32	32·16	31·74	31·98	32
Total Protein and derivatives (%N × 6·38),	25·84	25·96	25·96	26·15	26·66	27·02	27·11	27·43	26·73	26
Fat, total ether extract, - - -	32·41	32·76	33·48	33·28	33·71	34·24	34·25	34·29	34·23	34
Ash, - - - - -	3·83	3·48	3·22	3·58	3·49	3·74	3·75	4·02	3·87	3
Undetermined, - -	2·24	2·55	2·72	2·99	3·44	2·68	2·73	2·52	3·19	2
Milk sugar Lactose, -	1·00	Trace.	Trace.	...	...	...	...	...	...	
Acidity expressed in terms of Lactic Acid, - - -	0·94	1·01	1·85	1·91	2·05	2·02	2·02	2·00	1·93	1

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REPORT

ON

EXPERIMENT ON THE FEEDING OF PIGS

CARRIED OUT

At CALDERWOOD ESTATE, EAST KILBRIDE,

BY

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Report on an Experiment on the Feeding of Pigs at Calderwood Estate, East Kilbride.

Objects of the Experiment.

The primary object of this experiment was to test the efficacy of palm-nut cake or meal as a constituent of the ration for fattening pigs. The Directors of the Scottish Co-operative Wholesale Society were anxious to ascertain, for various reasons, whether this foodstuff could be economically used for pig-feeding, and the experiment was undertaken at their suggestion and carried out, under the supervision of the College, by the Manager of the Calderwood Estate, Mr. Geo. G. Young. At the same time, it was considered that a favourable opportunity was presented for obtaining some reliable data on the economics of pig-feeding, and this object was kept in view in designing and conducting the experiment.

Scheme of the Experiment.

On 18th May, 1916, 37 home-bred pigs, averaging about 14 weeks old, and of uniform quality and thriftiness, were selected and weighed separately. These were fed on the same ration, including palm-nut cake, for a week, after which they were again weighed. A further selection of 32 pigs was then made, and these were divided into four lots, Lots I and II being hog or castrated male pigs, Lots III and IV unspayed sows or females. Lots I and III received no palm-nut cake, while the ration for Lots II and IV contained a proportion of that foodstuff. Hence, it was possible (1) *to compare the results from* 16 *pigs receiving palm-nut cake with those from an equal number getting no palm-nut cake;* and (2) *to compare the returns from* 16 *hog pigs as against those from* 16 *sow pigs.* Table I shows the initial live weight of the individual pigs, and it will be noticed (Table II) that Lots I and II averaged 113 lbs., compared with 94 lbs. for Lots III and IV—a difference of 19 lbs. per head in favour of the hog

pigs. Since the pigs were of the same average age, this difference is significant and worthy of attention.

Method of conducting the Experiment.

Housing.—The four lots of pigs were housed in four adjacent pens, each 13 feet by 9 feet, and with excellent flooring, ventilation, and lighting. Each pen has an open yard, 13 feet by 12 feet, with an easily adjustable sliding door—generally kept open during summer weather. The chief litter used was sawdust, with some peat moss, but very little was required and, indeed, a characteristic of the pigs throughout the experiment was their remarkable cleanness.

Rations used.—On 25th May, the pigs were put on the experimental rations for the first period, as follows :—

Lot I. (Hogs).	Lot II. (Hogs).	Lot III. (Sows).	Lot IV. (Sows).
4 parts common thirds.	4 parts common thirds.	As for	As for
4 ,, Indian meal.	4 ,, Indian meal.	Lot I.	Lot II.
1 ,, fish meal.	1 ,, fish meal.		
1 ,, "pig meal."	1 ,, "pig meal."		
	4 ,, *palm-nut cake.*		
Nutritive ratio—1 : 4·6.	Nutritive ratio—1 : 4·6.		

It may be remarked that the nutritive or albuminoid ratio is somewhat narrow, but this was due to the high market value of the starchy foods, such as Indian and barley meal. In fact the rations would have been cheapened *initially* by omitting Indian meal altogether. But it should be noticed that the two rations have the same nutritive ratio, and this is a desirable condition in such an experiment, although not often easily obtained.

After 9 weeks' feeding on the above rations a change was made on 27th July, as shown below, the principal objects being to widen the ratio and lower the cost of feeding :—

Lot I. (Hogs)	Lot II. (Hogs).	Lot III. (Sows).	Lot IV. (Sows).
2 parts common thirds.	2 parts common thirds.	As for	As for
2 ,, Indian meal.	2 ,, Indian meal.	Lot I.	Lot II.
4 ,, flour sweepings.	4 ,, flour sweepings.		
1 ,, fish meal.	1 ,, fish meal.		
1 ,, "pig meal."	1 ,, "pig meal."		
	4 ,, *palm-nut cake.*		
Nutritive ratio—1 : 5·4.	Nutritive ratio—1 : 5·2.		

The nutritive ratios here shown are still considerably narrower than they would have been had market prices for feeding-stuffs been normal, but it will be seen that the proportion of palm-nut cake is the same throughout the whole period of fattening.

Daily Rations.—At the beginning of the experiment Lots I and II received about 5 lbs. per head per day, Lots III and IV about 4 lbs. It was decided to increase the feeding according to the pigs' appetite, no more being given at each meal than was readily cleaned up. Although this method of determining the amount of food given is objectionable from some points of view, it is based upon common practice in pig-feeding and in this experiment brought out a very interesting point. Before the experiment commenced, difficulty had been experienced in getting the pigs to eat palm-nut cake. It was suggested that it should be mixed with thirds and "pig meal" and soaked in water for some 12 hours before feeding. This was tried, with the result that in the course of a few days the pigs acquired a distinct liking for it. Indeed, after the experiment was commenced, it was very early seen that Lots II and IV receiving palm-nut cake had a keener appetite than Lots I and III. After 9 weeks' feeding on this basis, Lot I had consumed an average of 5·44 lbs. per head per day, Lot II, 6·35 lbs.; Lot III, 4·4 lbs.; and Lot IV, 5·2 lbs. Calculation, however, showed that, although Lots II and IV were increasing more rapidly in live weight than Lots I and III, no adequate return was being given for the extra food consumed. Incidentally, therefore, it would appear that the theory (and practice) that pigs which are healthy and thrifty should get as much food as they can clean up at each meal is not invariably sound. In this case it was not.

During the second period, Lots I and II each consumed on an average $6\frac{1}{2}$ lbs. per head per day; Lots III and IV, $5\frac{1}{4}$ lbs. each.

Method of Feeding and Preparation of Foods.—It should be particularly noticed that all the pigs received their meals dry. The palm-nut cake was finely broken and then merely softened with water in order to make it more easily masticated. The

meals were mixed together, and fed three times daily at 6.30 a.m., 12.30 p.m., and 4.30 p.m., in troughs placed in the covered part of the houses. Clean water was regularly provided in troughs fixed in the outer courts.

The feeding of the meals in the dry state is sometimes said to lead to undue waste, but in this experiment, probably owing to the nature of the meals being fed, no fault could be found on this score.

Weighing the Pigs.—The pigs were weighed individually once a fortnight by means of a special cage fitted on to an ordinary weighing machine. After the first two weighings, this operation involved extremely little time and labour and no disturbance to the pigs.

Slaughtering the Pigs.—It was intended to slaughter the pigs as they reached a weight which would ensure not less than about 12½ stones (of 14 lbs.) carcase or dead weight, but owing to the unexpectedly high ratio of dead to live weight, the carcase weight for many of the pigs was considerably higher. The first batch of eight pigs was killed on 28th August, after 95 days' feeding on the experimental rations. These pigs were fasted the day previous to killing, weighed and sent in to a Glasgow Corporation slaughter-house, where they were slaughtered, and the carcases officially weighed when cool. Each succeeding batch was treated in exactly the same way, and the following table shows the dates of slaughtering, and the lots from which the various batches were drawn :—

No. of Plots.	Killed on 28th August.	Killed on 11th September.	Killed on 18th September.	Killed on 25th September.
I.	2	2	2	2
II.	4	3	1	0
III.	0	2	3	3
IV.	2	1	3	2

General Health and Thriftiness of the Pigs.—One very satisfactory feature of the experiment, and which goes far

to promote the reliability of the results, was that *not a single one of the 32 pigs proved to be an ill-doer.* In fact, the progress of the individual pigs was, on the whole, exceedingly uniform, and the general appearance of the pigs was, throughout the experiment, thrifty and pleasing to the eye. No trouble whatever was experienced with any of the ailments with which the pig-feeder has often to contend.

Discussion of Results.

TABLE I.—Showing Individual Results.

Lot I.—Hogs (without palm-nut cake).

No. of Pig.	Live weight at beginning of experiment.	Number of days fed.	Fasted live weight when killed.	Carcase weight.		Per cent. carcase weight of live weight. *
	Lbs.		Lbs.	St.	lbs.	
1	125	95	263	14	8	77·6
7	101	116	247	14	6	81·8
16	114	116	246	13	12	78·8
20	140	95	264	15	0	79·6
25	122	109	255	13	10	75·3
33	93	123	214	12	0	78·5
34	97	123	231	13	1	79·2
36	116	109	243	13	0	74·9

Lot II.—Hogs (with palm-nut cake).

2	130	95	247	14	1	79·7
8	99	109	248	13	12	78·2
9	114	95	242	13	7	78·1
21	127	95	246	14	0	79·7
24	103	109	252	14	0	77·8
28	100	109	233	13	4	79·8
29	141	95	244	13	0	74·6
35	95	116	233	13	0	78·1

* "Carcase weight" means weight of scraped carcase after removal of stomach, intestines, heart, lungs, and liver.

Lot III.—Sows (without palm-nut cake).

3	85	116	233	12	7	75·1
4	94	123	227	12	11	78·8
5	99	116	252	14	0	77·8
6	73	123	186	10	3	76·9
11	82	123	215	12	2	79·1
13	99	109	248	13	11	77·8
23	117	109	244	13	7	77·5
37	101	116	257	14	3	77·4

Lot IV.—Sows (with palm-nut cake).

10	95	123	235	12	2	72·4
12	91	116	230	12	7	76·1
14	63	123	187	9	12	73·8
15	109	109	263	14	1	74·9
17	93	116	233	12	7	75·1
19	76	116	232	12	9	76·3
27	107	95	245	13	4	76·0
32	116	95	258	13	10	74·4

Table I.—It was originally intended that accurate records should be kept of the progress of each pig from week to week, but a number of the identification ear-tabs were torn off and lost at various times in the early part of the experiment, and it was not considered advisable to use the tattooing apparatus on fattening pigs of such age and strength. Hence, although Table I is a perfectly reliable record in the majority of cases, in a few there is some doubt. Nothing further will be said regarding the individual pigs beyond to remark that, taking this table as substantially accurate, the records show, as already stated, a satisfactorily uniform rate of progress for the individual pigs in each lot.

TABLE II.—Showing Summary of Gains in Weight.

No. of Lot.	Average initial live weight.	Average number of days fed.	Average fasted live weight when killed.	Average total increase in live weight.	Average daily increase in live weight.	Average carcase weight.	Per cent. carcase weight of live weight.
	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	
I.	113	111	245	132	1·19	192	78·4
II.	113	103	243	130	1·26	190	78·2
III.	94	117	233	139	1·19	180	77·2
IV.	94	112	235	141	1·26	176	74·9
Average.	103½	110¾	239	135½	1·22	184½	77·2

TABLE III.—Showing Details of Food Consumption.

No. of Lot.	Total meal consumed.			Meal consumed per pig.	Meal consumed per pig per day.	Meal required per lb. of increase in live weight.	Meal required per stone of carcase.*
	Cwts.	qrs.	lbs.	Lbs.	Lbs.	Lbs.	Lbs.
I.	46	3	4	655	5·90	4·96	47·8
II.	47	0	19	660	6·41	5·08	48·5
III.	39	2	24	556	4·75	4·00	43·2
IV.	41	3	17	586	5·24	4·16	46·6
Average.	43	3	16	614½	5·55	4·55	46·7

* In this case and also in the corresponding columns of Tables IV, VII, and VIII, it is clear hat only the cost of meal *during the fattening period* is here included, whereas it is the total carcase eight produced from birth which is taken. For purposes of comparison, however, this discrepancy s of little account, and especially since the total cost per stone of carcase is calculated in Table V.

Tables II and III.—The most striking feature of Table II is the last column, showing *the percentage dressed carcase weight of fasted live weight* when killed. It has been said that this was unexpectedly high, and some suggestions may be offered to account for it. In the first place, it will be noticed (Table I) that the high percentage is not confined to any one lot, nor is it peculiar to the heavier pigs. Further, it cannot be due to the palm-nut cake, for, although Lot IV dressed 2·3 per cent. less than Lot III, the difference between Lot II and Lot I was only 0·2 per cent. [The relatively low percentage of carcase shown by Lot IV was one of the surprises

of the experiment, since this lot all along was noted for the keenness of its appetite and thriftiness in appearance.] One is forced to conclude that the true explanation of this gratifying result lies in the "dry feeding." It is well known that grass-fed cattle or pigs fattened largely on whey do not dress so heavy a carcase as cattle fattened in houses during winter, or pigs fattened with a less watery ration; and it is only going a step further to assume and to maintain that pigs receiving no more water than they desire will make firmer flesh, and have less bulk and weight of internal organs than those which are compelled to drink larger quantities of water with their food than they would otherwise do. It is also to be expected that in the case of pigs taking their meals dry the salivary and other digestive juices will have a better chance to perform their functions than where they are immediately and compulsorily diluted with water. On the other hand, it is generally held that a narrow nutritive ratio, *i.e.*, very rich feeding, tends to increase the percentage of offal. This experiment demonstrates quite clearly that, however true this may be with the common methods of feeding, it is not always so where the meals are fed dry.

It is worth remembering that, had the average percentage of carcase to live weight been 73 (a very satisfactory figure) instead of 77·2, this would have meant a reduction of nearly 23 stones in the yield of pork, worth at current market price about £14 or 8s. 9d. per pig.

Table II shows that the heavier feeding of Lots II and IV shortened the duration of the fattening period by 8 and 5 days respectively, compared with Lots I and III, but it will be shown later that the advantage so gained is more than counter-balanced by the increased cost of the feeding.

The average daily gain in live weight per pig, as shown in Table II, works out at 1·22 lbs., or 8·54 lbs. per week. This does not appear very high when compared with published figures of other pig-feeding experiments, but the really important figure, the *meal required per lb. of increase in live weight*, works out (Table III) at an average of 4·55 lbs., which must be considered very satisfactory in view of the age of the pigs when the trial commenced. It is here that the error of

judging only by increase in live weight is exposed. Lots I and III gained only 1·19 lbs. per head daily, as against 1·26 lbs. for Lots II and IV; but while Lots II and IV required an average of 4·62 lbs. of meal to produce 1 lb. increase in live weight, Lots I and III required only 4·48 lbs. This, however, is merely one example of the Law of Diminishing Returns, which plays a very important part in determining the profit from all farming operations.

The average ration of 5·55 lbs. daily is by no means heavy, but it is questionable if heavier feeding would have given such a satisfactory net return.

The last column of Table III emphasises the *importance of determining not only the increase in live weight but also the carcase weight.* Thus, when calculated in terms of live weight, Lot I required about 16 per cent. more meal than Lot IV in order to give the same increase, but when taken in carcase weight the difference in favour of Lot IV is less than 3 per cent.

TABLE IV.—Showing Details of Cost of Feeding.

No. of Lot.	Total cost of meal consumed.			Cost of meal per pig.			Cost of meal per pig per day.	Cost of meal per lb. of increase in live weight.	Cost of meal per stone of carcase.
	£	s.	d.	£	s.	d.	d.	d.	
I.	21	11	7	2	13	11	5·83	**4·90**	**3/11·2d.**
II.	22	18	8	2	17	4	6·68	**5·29**	**4/2·7d.**
III.	18	3	0	2	5	5	4·66	**3·92**	**3/6·4d.**
IV.	20	3	10	2	10	6	5·41	**4·30**	**4/0·2d.**
Average.	20	14	3	2	11	9	5·64	**4·61**	**3/11·2d.**

Table IV practically translates Table III into terms of money, and serves to confirm the various conclusions arrived at under that table. For example, (1) the cost of meal per lb. of increase in weight is greater with Lots II and IV than with Lots I and III respectively; and (2) although the difference between Lots I and IV as regards cost of meal

per lb. of live weight increase is 0·6d. or 8·4d. per stone, the difference per stone of carcase is only 1d. in favour of Lot IV.

Special attention may be drawn to the last column of this table in which it is shown that, taking current prices for the summer of 1916, the *cost of food, during the fattening period, per stone of pork* produced is, for an average of 32 pigs, almost 4s. In this case, all the foods were purchased and charged at purchase price.

TABLE V.—Showing Details of Total Cost of Production.

No. of Lot.	Initial Cost of Pig.	Cost of Food during Fattening.	Cartage of Food, Pigs, &c.	Labour.	Rent of House.	Risk.	General Expenses.	Interest on Capital.	Total Cost per Pig.	Total Cost per Stone of Carcase
	£ s. d.	£ s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	£ s. d.	s. d.
I.	1 8 0	2 13 11	2 0	4 7	1 0	2 6	2 6	1 6	4 16 0	7 0
II.	1 8 0	2 17 4	2 0	4 3	1 0	2 6	2 6	1 6	4 19 1	7 3
III.	1 8 0	2 5 5	2 0	4 10	1 0	2 6	2 6	1 6	4 7 9	6 10
IV.	1 8 0	2 10 6	2 0	4 8	1 0	2 6	2 6	1 6	4 12 8	7 4
Average	1 8 0	2 11 9	2 0	4 7	1 0	2 6	2 6	1 6	4 13 10	7 1

N.B.—Had it been necessary to purchase the pigs at the time the experiment commenced, the hogs would have cost about 65s. each, the sows about 62s. 6d., and the relative total cost per stone of carcase for the four lots would have been:—Lot I, 9s. 9·1d.; Lot II, 10s. 0·3d.; Lot III, 9s. 6·2d.; and Lot IV, 10s. 1·4d.; or an average of 9s. 10·2d. per stone.

Table V.—In this table an attempt has been made to calculate the *total cost of production of a stone of pork* during the summer of 1916, and under such circumstances as prevailed at Calderwood Estate. In passing, it may be remarked that an estimate of the cost of food per stone of pork is likely to be highly misleading unless it is accompanied by an estimate of the *total* cost. A reference to the table shows, that with 32 home-bred pigs the cost of food during fattening makes up only about 55 per cent. of the total cost, while with purchased pigs only about 40 per cent. of the total cost would have represented food. In this case, the pigs were all home-bred, and an estimate of the total cost of production up to the beginning of the experiment has first to be made. After careful calculation, this was fixed at an average of 28s. per

head. It is not necessary to discuss in detail the other items of the table except to say that these were arrived at after a full consideration of all the circumstances of the case and may be taken as substantially correct; they are, at anyrate, not too low.

On the other hand, had it been necessary to purchase the pigs for this experiment, the initial cost would not have been less than 65s. per head for the hogs, and 62s. 6d. per head for the sows, which would have resulted in raising the total cost per stone of carcase from 7s. 1½d. up to 9s. 10d.—an increase of 2s. 8½d. In other words, the *profit from breeding the pigs* in this case amounted to 2s. 8½d. per stone of pork produced, or 35s. 9d. per pig.

TABLE VI.—Showing Details of Returns and Net Profits.

No. of Lot.	Average Return per Carcase.	Average Net Profit per Carcase.	Total Net Profit per Eight Pigs.	Average Net Profit per Stone, Pigs Home Bred.	Average Net Profit Per Stone had Pigs been Purchased.
	£ s. d.	£ s. d.	£ s. d.	s. d.	s. d.
I.	8 8 0	3 12 0	28 16 0	5 3	2 5·9
II.	8 6 3	3 7 2	26 17 4	4 11·6	2 2·7
III.	7 17 6	3 9 9	27 18 0	5 5	2 8·8
IV.	7 14 0	3 1 4	24 10 8	4 10·5	2 1·6
Average	8 1 5	3 7 7	27 0 8	5 1·5	2 4·8

Table VI.—In all feeding, as indeed in other experiments, the ultimate test must be the *net profit* from the various treatments, and this is shown in Table VI. The pork was sold at 12s. 3d. per stone (14 lbs.) dressed weight, and the first column shows the average monetary return from each lot. Here a very striking point emerges. The last column of Table V shows that Lot III cost 6s. 10d. per stone of pork while Lot I cost 7s., and one would be tempted to conclude that Lot III had proved more profitable than Lot I. But Table VI indicates that this is not so. The average net profit from Lot I amounts to £3 12s. per pig, while that from Lot III

is only £3 9s. 9d.—a difference of 2s. 3d. per pig. The explanation lies in Table II. In the case of Lot I the profit of 5s. 3d. per stone (Table VI) was made on 13 stones 10 lbs.; while, for Lot III, the greater profit of 5s. 5d. per stone was made on only 12 stones 12 lbs. To take a similar case, it is clear that a 60 bushel per acre crop of oats yielding a net profit of 4d. per bushel, will give a greater total profit than a 40 bushel per acre crop showing a net profit of 5d. per bushel. Putting the case more generally, this is merely an example of the desirability of having as large a turnover as possible; the greater the turnover, the smaller need be the percentage profit in order to get the same total profit, while, with the same percentage profit, the total profit varies according to the turnover. Incidentally, this is one of the factors which militates in favour of quick fattening of live stock generally and especially of pigs, which lend themselves to forced feeding.

It should be pointed out that no mention has been made in the above tables of the *value of the manure* produced nor of the cost of the litter, and for various reasons. It is quite true that where it is possible to completely utilise all the solid and liquid excreta, the value of the manure produced in pig feeding will be considerable — in this case it would approximate to £13 or 11s. per pig—and any estimate of the total net returns must take account of it. But under ordinary circumstances, where most of the liquid and part of the solid excreta are lost, it is safe to say that the manure per pig will not be worth more than about 5s. In this experiment, the manure values from the various lots would be practically the same, and hence their omission will not affect the main conclusions, which are essentially based on comparisons. As for the other conclusions, the introduction of this question of manurial values would have rendered the figures much more open to question than they otherwise are. In any case, in determining whether to go in for pig-feeding for profit, the feeder is not likely to be greatly influenced by considerations of manure values.

TABLE VII.—Showing comparison of Lots I and III (no palm-nut cake) with Lots II and IV (palm-nut cake).

No. of Lots.	Average Initial Live Weight.	Average Daily Increase in Live Weight.	Average Carcase Weight.	Average per cent. Carcase Weight of Fasted Live Weight.	Average of Meal Consumed per Day.	Average of Meal required per lb. increase in Live Weight.
	Lbs.	Lbs.	Lbs.		Lbs.	Lbs.
Average of Lots I and III,	103·5	1·19	186	77·8	5·32	4·48
Average of Lots II and IV,	103·5	1·26	183	76·5	5·82	4·62
Difference in favour of Lots I and III,	—	(−)0·07	3	1·3	0.50	0·14

TABLE VII.—*Continued.*

No. of Lots.	Average Cost of Meal per Lb. of Increase in Live Weight.	Average Cost of Meal per Stone of Carcase.	Average Total Cost per Stone of Carcase.	Average Return in Carcase.	Average Net Profit.
	D.	S. D.	S. D.	£ S. D.	£ S. D.
Average of Lots I and III,	4·41	3 8·8	6 11	8 2 9	3 10 10
Average of Lots II and IV,	4·79	4 1·4	7 4	8 0 1	3 4 3
Difference in favour of Lots I and III,	0·38	0 4·6	0 5	0 2 8	0 6 7

Table VII.—It is now possible to discuss more fully the relative returns from Lots I and III receiving no palm-nut cake, and Lots II and IV, which received a proportion of palm-nut cake in their rations. It will be seen that Lots II and IV have a slight advantage in daily gain in live weight, but in

every other respect Lots I and III have a superiority, represented ultimately by the greater gain of 6s. 7d. per pig. An examination of Tables II-VI shows that the advantage obtains with both sexes, but it is somewhat more marked with the sows than the hogs. Three causes of this difference may be noted; (1) the higher percentage of carcase from Lots I and III. This only applies to the sow lots and is not likely to be due to the inclusion of palm-nut cake in the ration of Lot IV. If Lots II and IV had dressed 77·8 per cent. carcase, instead of 76·5 per cent., the difference in the last column of the table would have been reduced by 2s. 8d. per pig, leaving only about 4s. per pig to be accounted for. This difference is perhaps within the limits of experimental error, but it may be also noted, (2) that the meal required to produce 1 lb. increase in live weight is greater for Lots II and IV than for Lots I and III; and (3) that the average cost per ton of the palm-nut cake ration is a little higher than that of the ration for Lots I and III.

Altogether, it is justifiable from the records of this experiment to conclude that, when used in the proportion already given, palm-nut cake forms, under existing conditions, a suitable and economical constituent of a ration for fattening pigs.

TABLE VIII.—Showing comparison of Lots I and II (Hogs) with Lots III and IV (Sows).

No. of Lots.	Average Initial Live Weight.	Average Daily Increase in Live Weight.	Average Carcase Weight.	Average per cent. Carcase Weight of Fasted Live Weight.	Average of Meal Consumed per Day.	Average of Meal required per lb. Increase in Live Weight.
	Lbs.	Lbs.	Lbs.		Lbs.	Lbs.
Average of Lots I and II,	113	1·22	191	78·3	6·15	5·02
Average of Lots III and IV,	94	1·22	178	76·0	4·99	4·08
Difference in favour of Lots I. and II.	19	—	13	2·3	(−)1·16	(−)0·94

TABLE VIII.—*Continued.*

No. of Lots.	Average Cost of Meal per Lb. of Increase in Live Weight.	Average Cost of Meal per Stone of Carcase.	Average Total Cost per Stone of Carcase.	Average Return in Carcase.	Average Net Profit.
	D.	S. D.	S. D.	£ S. D.	£ S. D.
Average of Lots I and II,	5·09	4 0·9	7 1·8	8 7 1	3 9 7
Average of Lots III and IV,	4·11	3 9·3	7 1·2	7 15 9	3 5 6
Difference in favour of Lots I and II,	(−)0·98	(−)0 3·6	(−)0 0·6	0 11 4	0 4 1

Table VIII.—It is a common opinion with pig-feeders that unspayed sow pigs do not fatten so economically as hogs, for the reason that the sow pig is likely to receive a set-back each time she comes in season, but very few actual trials have been recorded on the point. Table VIII compares the results from 16 hogs with those from 16 unspayed sows. It will be seen that the hogs consumed on an average 1·16 lbs. more meal daily than the sows, but the former required 5·02 lbs. of meal to produce 1 lb. of live weight increase whereas the latter required only 4·08 lbs. Financially, the advantage continues to lie with the sows until the final calculation of net profit is made, when the hogs take the lead to the extent of 4s. 1d. per head, although Lot III is better than Lot II by 2s. 7d. per head.

This latter fact gives the clue to what appears to be the chief factor determining the difference in net profit between the hogs and the sows. If the sows had dressed 78·3 per cent. carcase instead of 76·0 per cent., in lieu of the difference of 4s. 1d. per head in favour of the hogs, there would have been one of 7d. per head in favour of the sows. In other words, although the average net profit per stone of carcase is greater for the sows, owing to the greater carcase weight of the hogs

(due partly to the greater percentage of carcase), the total profit from them is greater than that from the sows. [See also under Table VII.] But it should be kept in mind that, if the pigs had been purchased, the sows would have cost at least 2s. 6d. per head less than the hogs, and this would have reduced the balance against them to only 1s. 7d. per head—in all probability less than the experimental error.

Quality of Pork.—The report on the quality of the carcases received from the purchasers was to the effect that it was all that could be desired, the flesh being firm, of good colour, and with plenty of lean meat. No difference could be detected, neither in the carcase nor when cured, between the pigs which did and those which did not receive palm-nut cake, nor between the hogs and the sows.

Method of Sale.—It should be noted that in this case the pigs were sold per stone of carcase according to quality, which was judged after the pigs had been hung up. Hence, (1) there was every inducement to feed so as to ensure as high a percentage of carcase as possible, whereas, had the pigs been sold on foot at so much per head, less importance would have attached to this point; and (2) the price was fixed according to the quality of the carcase and not, as in many cases, at so much per stone irrespective of quality, provided a certain standard is reached. It may be said, therefore, that with the method of sale adopted, the full value of the pigs, from every point of view, was secured by the feeder, and every inducement was offered him to feed not only for high weight of carcase but also for quality.

Summary of Conclusions.

1. *Under existing conditions and when used in the proportion stated in this report—two-sevenths of the total meal mixture—palm-nut cake may be considered a suitable and economical food for fattening pigs.*

2. No difficulty need be experienced in getting pigs to acquire a taste for palm-nut cake, after which it seems to have the effect of increasing their appetite.

3. The experiment gives little support to the opinion that unspayed sows are less profitable for fattening than hogs. On the contrary, the sows gave a more profitable return per lb. of meal consumed than the hogs and, but for the fact that they dressed a lower percentage of carcase, would also have yielded as high a net profit.

4. The percentage of carcase to fasted live weight was abnormally high, and it may be strongly suggested that this result has some connection with the dry method of feeding the meals. Further trials are desirable to test the validity of this theory.

5. The great importance of determining the carcase weight in experiments with pigs, and especially when the price of pork is high, is clearly established. In this case, had the final live weight only been taken, the conclusions would, in certain important respects, have been just the opposite from what they correctly are.

6. It is further established that, although it is desirable to determine the daily increase in live weight per pig, it is much more important to know the quantity of meal required to produce unit increase in live weight, while the final test should be the quantity of meal required to produce unit increase in carcase weight.

7. The practice of giving fattening pigs as much food as they can clean up at each meal does not appear always to be economical. The heavier feeding may give quicker increase in weight, but at a greater cost per lb. of increase.

8. Under existing conditions, the total cost of a stone of pork amounted, in the case of 32 home-bred pigs, to fully 7s., of which the cost of food during the fattening period formed about 55 per cent. Had the pigs been purchased as stores, the respective figures would have been 9s. 10d. and 40 per cent.

9. The quality of the flesh was excellent, and no difference could be detected, due either to the inclusion of palm-nut cake or to the sex of the pigs.

10. In order to secure highest possible returns from up-to-date methods of pig feeding, the fat pigs should be sold at so much per stone of dressed weight, and according to the quality of the flesh.

11. Under existing conditions, pig feeding, even with meals and water only, appears to be a remunerative industry, and especially where the feeder is also the breeder.

Acknowledgments.

The writer wishes to take this opportunity of acknowledging, on behalf of the Governors and Principal, the indebtedness of the College to the Directors of the Scottish Co-operative Wholesale Society for rendering this experiment possible, and he further desires to thank Mr. Geo. G. Young, Manager at Calderwood Estate, for the hearty support he gave in designing and carrying out the experiment, and for the extreme care he showed in its conduct from day to day. His thanks are also due to the two pig feeders at Calderwood, who took a keen personal interest in the experiment. Lastly, he wishes to acknowledge the valuable help he received in designing, supervising, and reporting on the experiment from his colleague, Mr. James M'Cutcheon, Extension Lecturer for Lanarkshire.

Composition of Foods used in Experiment.

	Total Albuminoids. %	Oil or Ether Extract. %	Carbo-hydrates. %	Fibre. %
Common Thirds, ...	15	4·5	57	8
Indian Meal, ...	10·5	5	70	2
Flour Sweepings, ...	7·5	7·2	65	2
Fish Meal, ...	54	5	—	—
"Pig Meal,"	12	4	64	—
Palm Nut Cake, ...	18	8	44	12

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NOTES

ON

MEDICINAL PLANTS

BY

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INSTRUCTION IN HORTICULTURE.

EXTENSION LECTURES AND DEMONSTRATIONS.

The Governors are prepared to consider applications for the services of the Lecturers in Horticulture, not only for the delivery of Lectures, but also for visits to orchards and gardens, with a view to giving advice as to their improvement.

The services of the Lecturers are given free, and the travelling and other personal expenses paid, but the Local Committee is expected to make all necessary arrangements for the Lectures and Demonstrations, including advertising, use of Schoolroom or Hall, &c.

Evening Classes in Horticulture for young Gardeners and others interested in gardening are held during the winter session, at the Agricultural College, Blythswood Square, Glasgow. Particulars of these and other classes may be obtained from the Secretary.

Copies of this Bulletin may be had on application.

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NOTES ON MEDICINAL PLANTS.

INTRODUCTORY.

The principal reasons for issuing this Bulletin are :—

(1) To discuss the possibilities and limitations of the cultivation, and collection from wild sources, of medicinal plants in Scotland.

(2) To supply information on herb-growing to the general public.

(3) To present in handy form a list of the principal hardy plants used in the practice of medicine and by herbalists.

(4) To give some important particulars about the plants themselves.

It is hoped that the information given may be of use to anyone contemplating herb-growing or herb-collecting. Fuller details of cultivation, collection, drying, marketing, yield, prices, &c., will be found in the various books mentioned on page 118.

GENERAL REMARKS.

In many old gardens it was usual to find a portion set apart for the cultivation of medicinal herbs for home use, but during recent years these herbs have been much neglected, and in many gardens have entirely disappeared. At the

present time only a few of the very common herbs used in cookery are found in cultivation in our gardens.

In addition to a well-stocked herb garden, our forefathers knew where to find certain other medicinal herbs on the hills, in the meadows, or by the waterside. Fifty years ago the herbalist was a well-known figure of the countryside, our drugs being then either home-grown or collected from wild sources. We still use most of the same medicinal herbs as a basis for many varied medicines, but for years we have allowed the people of Central Europe to supply our wholesale druggists with the roots, stems, leaves, flowers, and seeds required in the dispensing of medicine.

Practically the whole of the herbs used in medicine in this country are purchased by a few large firms of wholesale druggists, who, in turn supply the chemist and herbalist. Home-grown herbs were almost ousted from the markets previous to the outbreak of the Great War in 1914. In 1913, the value of our imports of herbs amounted to £17,000, yet a large number of these plants are found wild in this country, whilst many others are quite hardy and capable of being cultivated here.

The collection and cultivation of medicinal and other herbs is well organised on the Continent, and it has long been the practice there for peasants, and often their children, to collect these plants in a wild state. The herbs, roots, &c., thus gathered are then dried—sometimes very indifferently, and occasionally allied plants are substituted for the proper species or varieties—and afterwards sold either in local markets or to collectors who make periodical calls.

Very low prices are, as a rule, paid for herbs collected in this way, hence Continental dealers have been able to offer these plants to our wholesale druggists at cheaper rates than would pay the home grower or collector, and it is due to this fact that the decline of the herb industry in this country must be attributed.

A certain amount of knowledge is necessary before anyone can grow or collect herbs, otherwise errors may be made, hedge parsley or beaked parsley, for example, being gathered for hemlock. In country districts children might be taught

to recognise useful local plants, and those that are poisonous or otherwise harmful to live stock. It is desirable that a list should be compiled of wild plants of economic importance or of a poisonous character in every parish, for reference in public schools, village libraries, or recreation rooms. This work could be undertaken by some intelligent person with a taste for nature study; say the minister or schoolmaster. Anyone in doubt as to the names or uses of plants met with should send specimens to the Agricultural College for identification and advice.

THE NATIONAL HERB-GROWING ASSOCIATION.

Owing to the scarcity of some drugs and the consequent high prices now ruling, it was thought that an opportune moment had arrived for taking steps to revive an old British industry, and to further this object a Herb-growing Association was formed at the commencement of the war, members of which pay a fee of 5s. per annum, and receive leaflets, and also advice on what to grow or collect, how to dry, the extent of the demand and current prices for herbs. The Association is willing to sell its members' produce on commission, when properly prepared. Seeds or plants may be purchased from the Association or from fellow-members by those wishing to take up herb-cultivation. The whole of this work is regarded as a patriotic movement. The head offices of the Association are at 6th floor, Queen Anne's Chambers, Westminster, S.W., with branches in various parts of the country. Central drying stations are to be established and a local secretary appointed, as far as possible, in each county. Members will thus be able to send their produce—grown or collected wild—to the local stations to be dried in the most approved manner, and marketed on an organised co-operative system. This is of great importance and convenience to small growers who may have only a few pounds of the dried herb for disposal. The wholesale druggist or distiller usually buys by the hundredweight or ton, and does not wish to be troubled with small quantities. This is where co-operation is needed in order to

deal with the small quantity of produce, and to check the over-production of certain herbs by small growers in the aggregate. Undoubtedly careful cultivation of the right plants on any considerable scale may show good profits during the next few years, but in the long run amateur herbalists should not take up the work with the idea of making large sums of money out of small plots of ground. However, an outlay of a few shillings for seeds or plants of some particular kind of herb may provide a moderate return. The following from *The Gardener's Chronicle*, November 18th, 1916, page 247, is interesting and instructive as showing what is possible under certain conditions and owing to the scarcity of medicinal plants :—

"*Belladonna.*—I sowed last March a few ounces of seed of the above, picking out into seed-beds 18 inches each way. From 244 square yards of seedlings (which have grown very fast, many of which were, in September, 3 feet high, and producing ripe seed) I have picked leaves four times, and have sold—

18 lbs. of dry leaves at 5s. 6d., ...	£4	19	0
267 lbs. of fresh leaves at 1s., ...	13	7	0
	£18	6	0

working out at 1s. 6d. per square yard, or £363 per acre. The plants have now been raised and transplanted, many of the roots being above 1 inch in diameter. The soil is light, and received a dressing of chalk a few years ago. I shall be glad to know whether this rate of growth is not unusual, also whether ripe seed is often produced the first year from seed, viz., in about 6 months.—H. Clinton Baker."

Cottagers and others with gardens and allotment holders, if invited by the Association to take up the cultivation of herbs, should have a guarantee that the produce, if in good condition, would be purchased by the Association at current prices or at contract prices to be arranged beforehand, according to the kind of herb. It is only in this way that

people will be induced to cultivate medicinal herbs. Only a limited number of kinds should be grown by one person.

Seeds or plants could be supplied at a cheap rate either by the National Association or through one of its branches, or arrangements could be made with nurserymen and seedsmen for the supply of plants and seeds.

The Agricultural College already possesses a herb garden —for the trial of as many kinds as possible—at Kilmarnock; and other educational authorities, such as the Provincial Committee for the Training of Teachers, could also grow a small collection of these. It is important that people interested in this branch of industry should have opportunities to become familiar with medicinal plants.

The gathering of wild plants, herbs, flowers, roots, &c., should be organised. Enthusiastic women with spare time, school children, or boy scouts would, perhaps, undertake this work; the supplies thus gathered to be sent to the central drying depot. The collectors might be instructed how to dry flowers and leaves as they are gathered, thus preventing the possibility of waste and also saving carriage on bulky material.

A campaign of education should be inaugurated to familiarise people with the plants that are required. Local secretaries could furnish a list of the plants to be found in each district; in this way would the cultivation, collection, drying, marketing, &c., of medicinal plants be properly organised.

Whether it will pay to embark on a large scale in the cultivation of medicinal and other herbs depends greatly on the experience and aptitude of the grower, the kind of soil, climate, facilities for drying, good markets, reasonable rent, capital to start with, and the prices obtainable when the produce is grown. It must be remembered that some of the plants will not be ready for marketing until the lapse of two or three years after planting, hence the importance of a sufficient capital to tide over the first few years.

In any case it will be necessary to proceed cautiously, growing a few kinds as a side line in the garden or holding in the first instance, until experience teaches what to grow and what not to grow. After all, it must be borne in mind

that the demand for herbs is limited compared with the demand for food products, and market gardeners and small holders will be well advised to cater for the people's food rather than its medicine, especially when so many persons are already engaged more or less successfully in the cultivation and collection of medicinal herbs as a result of articles which have appeared in the public press. Highly-coloured pictures are sometimes painted of the profits to be derived from this branch of cultivation, and it is to be feared that many people taking up herb-growing without previous experience of gardening or farming will meet with failure, in the same way as many did with French gardening or intensive cultivation, so widely boomed about ten years ago.

As there are already in existence several old-established herb farms and gardens, the proprietors of which are fully alive to the possibilities of herb-growing, and therefore ready to adapt themselves according to the demand for certain plants, the beginner should remember that he would have to compete with these. Of course there may be room for other growers, but it will probably prove safer, on the whole, to take up the cultivation of vegetables, fruit, or flowers as a means of livelihood rather than medicinal plants, except in special cases.

Would-be growers should not attempt to cultivate too many kinds, but should give special attention to a few plants known to succeed in their locality, and also make a careful study regarding cultivation and methods of drying and marketing in order to obtain good results.

CULTIVATION.

Full details of cultivation of all the various kinds of plants used in medicine cannot be given here. It is sufficient to state that land in a good clean state of cultivation and capable of producing farm and garden crops would be suitable for the cultivation of herbs which are hardy to the district.

The seeds of annual herbs are usually sown during April or May, according to locality or hardiness of the plants. The

soil should be carefully prepared, made fine and firm, and the seed sown thinly. The resulting seedlings will require careful thinning when large enough to handle, selecting showery weather for this purpose, if possible, so that ample space is given for full development of the plants. Frequent hoeing should be done among the plants to keep down weeds and to encourage quick growth of the crops until ready for harvesting.

The biennial kinds are usually sown in June or July and thinned or transplanted during the summer or autumn. The soil should be kept free from weeds during the season of growth. Harvesting usually takes place the year following the sowing of the seed.

Perennials may be planted or replanted during the autumn or spring, care being taken to give sufficient space to each plant according to size and habit of growth. It is important to keep the ground free from weeds, and to provide some means of support for tall or weak-growing kinds. The harvesting of the crops—whether leaves, stems, roots, fruits, or seeds—should be done when in the proper state of development. Many of the perennial kinds are of strong growth and of a spreading habit, and on that account will require division and replanting every two or three years. This will tend to promote a healthy and vigorous growth. In the case of plants that are not quite hardy, some kind of protection, such as a garden frame or greenhouse, will be necessary during the winter. Those that are of very slow growth may be divided or cuttings taken so as to increase the stock.

Plants which have bulbs, corms, tubers, or rhizomes may be lifted and divided if it is found desirable to increase the stock of these, or for the promotion of more vigorous growth when the growing season of each kind is past, or just before the new growth commences.

It is important to remember that medicinal herbs, like other plants when brought under cultivation, are liable to the attacks of various insect pests and plant diseases, and considerable losses may be experienced unless a careful watch be kept and prompt measures taken for the prevention or destruction of such pests or diseases.

HERB DRYING.

Owing to the large amount of rain experienced during the summer of 1916 in the West of Scotland it was found very difficult to dry in the open air the many kinds of herbs collected.

Herbs for drying should be carefully gathered at the right season, cutting them, generally when the flowers begin to open, just above the ground or where the lower leaves have withered or changed colour. The herbs are tied into small bunches and hung up in an airy shed until dry. During fine weather, drying may take place in the open air, placing the herbs on lines, poles, or sticks; or they may be placed on sheets of canvas, paper, mats, or sacks, and then laid on a dry path fully exposed to the air. Wood frames may be constructed about six feet long by four feet wide, with canvas or wire netting nailed across for laying the herbs upon. An east wind is specially good for drying. The herbs should be placed under cover at night and also when it rains.

Greenhouses or garden frames that are empty or comparatively empty during summer may be utilised for drying purposes, though some shade to prevent undue scorching may be necessary. Specially constructed sheds with racks or shelves, and heated to keep out the damp and cause a free circulation of air would be a great convenience for a local branch, central drying depot, or wherever herbs are collected or cultivated extensively.

The evaporators manufactured by Messrs. Medcalfe & Co., Audrey Works, 141-142 Great Saffron Hill, London, E.C., and the British Fruit Evaporator Company, Ridsdale Road, Anerley, London, for drying fruits and vegetables, would also prove of great use in drying leaves, stems, roots, or seeds of choice medicinal or other herbs, such as foxglove and belladonna leaves, thyme, sage, mint, parsley, tarragon, &c.; or these may be dried in the kitchen, placed on the rack or in the oven with the door left open. When properly dried, the herbs should be placed in paper bags, boxes, or bottles, until required for use or for sending away.

Herbs should be of a uniform and good colour when dried. This adds greatly to their value. It is, therefore, important to gather when in the right condition and when the weather is dry. Roots and underground stems will of course require to be washed, and usually sliced, before drying.

Whatever system of drying is adopted it is important that it should be fairly rapid, so that the colour, flavour, and medicinal properties of the plants may be preserved as much as possible.

After the drying is complete, those intended for selling purposes should be tied into neat bunches or bundles of some definite weight, such as 7 lbs., 14 lbs., or 28 lbs.

Whenever possible a large quantity of each sort selected should be gathered and dried, a mere handful (except in the case of very rare plants) is of little use; moreover, drying tends to reduce the weight and bulk very considerably, and, after all, it is the dried plant or parts of the plant in most cases that is required by the druggist for medicinal purposes.

The majority of plants lose from 70 to 85 per cent. of moisture in drying. It therefore requires about 4 lbs. of fresh leaves to yield 1 lb. when dried. Belladonna leaves lose from 85 to 90 per cent. when dried.

When herbs are thoroughly dried and again exposed to the air they will absorb about 12 per cent. of moisture and become flexible, and are apt to deteriorate in quality; hence the importance of keeping quite dry until sent to the clearing-house or druggist.

YIELD AND PRICES.

It should be borne in mind that while the price of some of the more important drugs has increased enormously, there is only a limited demand for certain others, and it would be no difficult matter to overload the market with them. Thus a certain amount of co-operation is necessary to regulate the supply. Intending growers should seriously consider this point before embarking on herb-growing to any great extent.

The following particulars of yield and prices have been

adapted from Leaflet No. 288 issued by the Board of Agriculture and Fisheries, London. Chamomile flowers were formerly imported from Belgium, where an average price of £2 15s. per cwt. was obtained. By the end of the first month of the war £6 was asked for the previous year's Belgian flowers, while this year (1916) French-grown chamomile flowers have realised £7 10s. per cwt. It is estimated that home-grown flowers (dried) should be worth about 3s. per lb., and it is calculated that the yield of dried flowers would be about 4 cwts. per acre.

Foxglove leaves collected from wild plants and dried are worth about 8d. to 10d. per lb.

Belladonna leaves are worth about 1s. per lb. when dried, and the roots from £2 5s. to £3 5s. per cwt. It is estimated that 5 tons of leaves may be produced per acre.

Henbane home-grown plant yields 15 cwts. per acre, and sells normally at £7 per cwt.

Aconite root (dried) realises about 2s. per lb.

Blessed Thistle yields about 33 cwts. per acre of dried herb, worth about £50.

Dandelion roots, when dried, realise from £2 to £5 10s. per cwt. The yield is said to be 4 to 5 tons of fresh root in the second year after sowing.

Dill fruit "seeds" produce from 5 to 7 cwts. per acre, and sells at £1 10s. to £2 per cwt.

Fennel yields about 15 cwts. of fruit "seed" per acre, and sells at from £1 to £1 5s. per cwt.

Some of the prices mentioned above may at first appear quite good, but the labour and expenses of cultivation are very considerable, especially on land that has not been previously well cleaned.

POSSIBLE IMPROVEMENT OF MEDICINAL PLANTS.

It should be remembered that the character of the soil, method of manuring, and, especially, the climate has a great

influence in producing the scent, oil, and alkaloid percentage in these plants; thus a warm, dry climate would be more favourable on the whole than a cool, wet one.

The yield and also the medicinal properties of some plants may be largely increased by cultivation. This is probably due to less competition and an increased food supply, *e.g.*, chamomile, vervain, &c. On the other hand, cultivation of some poisonous plants has a tendency to reduce the poisonous principle rendering them comparatively harmless, *e.g.*, wild celery, annual bitter sweet (Solanum nigrum), and perhaps, to some extent, aconite. The foxglove is said to be of greater medicinal value when gathered in a wild state, certain strains of the wild plant yielding more "digitalin" than others.

Some attention should be paid to the improvement of medicinal plants, selecting those forms which give the greatest yield or contain the greatest percentage of the active principle. Plants tend to vary under cultivation, especially when raised from seed, and this offers a hopeful field for the improvement of these plants. Henbane behaves sometimes as an annual and sometimes as a biennial, and selection would be of some importance here. The pot marigold varies both in colour and size of its flowers; the best forms should therefore be selected. The chamomile is found in great quantity in some districts on moors, damp pastures, &c., but under cultivation increases in size of plant and flowers, the latter sometimes becoming double and therefore more valuable than the dwarf and single wild form.

Chemical research, too, in course of time will probably help us to determine which forms of medicinal plants yield the greatest amount of the active principle contained in the plants. Great possibilities exist in this direction for improvement, as was the case in determining the sugar content of sugar beet, sugar cane, and many other economic plants. Another direction in which chemical research may aid the science of medicine and the cultivator is by careful analysis of plants closely related to those in general use. It is well-known that, as a rule, allied plants possess similar properties, and might perhaps be used as substitutes; for example, the

following genera of plants used in medicine have more than one species or well-marked variety :—

Berberis (Barberry).
Chenopodium (Arrach).
Erythræa (Centaury).
Erythronium (Dog's Tooth Violet).
Euphorbia (Euphorbia, Sun Spurge).
Euphrasia (Eyebright).
Galium (Clivers, Bedstraw).
Gentiana (Gentian).
Geranium (Cranesbill, Alum-root).
Gnaphalium (Cudweed).
Hypericum (St. John's Wort).
Lamium (Archangel, Dead Nettle).
Papaver (Opium Poppy).
Rhamnus (Buckthorn, Cascara).
Symphytum (Comfrey).
Verbascum (Mullein).
Viola (Heartsease, Violet).

PLANTS USED IN MEDICINE.

Hundreds of different kinds of plants—herbs, trees, and shrubs—are used in medicine. A large number of these are natives of tropical and sub-tropical countries. It is only those from temperate parts of the world that are of interest to the home-grower or collector of medicinal plants.

Some medicinal plants are not amenable to cultivation, as it is very difficult to provide the exact natural conditions necessary for their growth, such as streams, ponds, bogs, moors, and woodlands. Examples :—

Water Plantain (Alisma).
Buckbean.
Maidenhair Fern.
Clubmoss.
Brooklime.
Calamus.
Water Germander.
Sundew.
Orchis.
Adder's Tongue.
Sweet Gale.

A few plants are of a parasitic or semi-parasitic nature, *i.e.*, growing upon or in association with other plants. Examples :—

Dodder.
Mistletoe.
Ergot.
Eyebright.
Mountain Flax.
Centaury.

Other medicinal herbs, though easily grown in the South or Midlands of England, are not hardy enough for the climate of Scotland, unless in mild places near the coast. Examples :—

Angelica.
Basil.
Castor Oil Plant.
Cumin.
Cucurbita.
Indian Hemp.
Lavender.
Rosemary.
Sweet Bay.
Tobacco.

Nearly all the plants mentioned below are fairly abundant in a wild state, finding just the right natural conditions best suited to their growth, and it would therefore scarcely pay to engage in their cultivation. Some of them are not of great medicinal value, but nevertheless are kept in stock by many herbalists. Examples :—

Bindweed.
Broom.
Burdock.
Butterbur.
Clivers.
Coltsfoot.
Couch Grass.
Cowslip.
Cuckoo Flower.
Daisy.
Dandelion.
Dead Nettle.
Dock.
Dog Mercury.
Elder (Bourtree).
Figwort.
Ground Ivy.
Groundsel.
Hedge Mustard.
Marsh Marigold.
Meadow Sweet.
Mouse Ear.
Plantain.
Ragwort.
Sanicle.
Self Heal.
Shepherd's Purse.
Silverweed.
Stinging Nettle.
Tormentil.
Water Cress.
Yarrow.

Many of the plants mentioned above may be of local occurrence, but if there is a demand for them they may be collected where they occur in plenty. In some cases, however, the plants may be greatly improved, and an increased yield obtained, by cultivation; for example, dandelion produces better roots when grown as a crop.

The following plants are worthy of the attention of cultivators of medicinal plants. They are of easy cultivation in Scotland, and there is a steady demand for most of them :—

Aconite.
Agrimony.
Aniseed.
Balm.
Baneberry.
Belladonna.
Bistort.
Caraway.
Chamomile.
Comfrey.
Coriander.
Elecampane
Fennel.
Feverfew.
Figwort.
Foxglove.
Greater Burnet.
Greater Celandine.
Green Mint.
Hemlock.
Hemp Agrimony.
Henbane.
Horehound.
Lily-of-the-Valley.
Marigold.
Marjoram.
Marsh Mallow.
Meadow Saffron.
Mugwort.
Mullein.
Opium Poppy.
Pennyroyal.
Peppermint.
Rue.
Tarragon.
Thornapple.
Turkey Rhubarb.
Valerian.
Vervain.
Wood Betony.
Woodruff.
Wood Sage.

TREES AND SHRUBS.

In addition to herbs used in medicine, quite a large number of trees and shrubs, both native and foreign, are also of medicinal value. The bark and wood are the parts most commonly employed, but leaves, flowers, fruit, and seeds of some kinds are also used.

There may be only a limited demand for some of these, and it is doubtful if it would pay to grow them for this purpose, with the exception of a few uncommon shrubs; certainly not in a garden or small holding. Rough or stony land may, however, be planted with trees and shrubs. They will take a long time to grow large enough for the production

of bark or fruit, but they may prove useful for shelter, ornament, or eventually as timber.

In obtaining the bark, either the whole tree or shrub is cut, or whole branches are cut and the bark removed, as the peeling of the bark causes the death of the tree or branch above where the bark has been peeled off. The principal kinds of trees and shrubs of medicinal value are included in the list on page 120.

LIST OF MEDICINAL PLANTS.

The following list of medicinal plants has been prepared as a guide to what plants are used in medicine, perfumery, &c. It is fairly complete as regards those that may be grown or collected in Great Britain. To include every hardy plant that has been used at one time or another in this country would make a very long list, therefore tropical and sub-tropical plants are not, except in a few cases, included in this list, as they cannot as a rule be successfully grown.

There may be only a limited demand for many of the plants included in the list, some having fallen into disuse or been superseded by the introduction of other kinds.

Where it is stated that the whole herb is used, this usually means the whole plant above ground, such as stem, leaf, flowers, &c.

When fruit is mentioned as the part used, this includes what is also popularly known as seed. In some cases it is the true seed that is used.

The underground portion of many plants is used in medicine, such as root, rhizome, bulb, corm, or tuber, all of these being regarded by some people as "roots."

In the following list the botanical names of the plants are placed in the first column and in alphabetical order, this being thought, on the whole, the most convenient for reference, as the common names are more numerous and vary in different localities. A list of common names is also given on page 144 for those unfamiliar with the botanical names of medicinal plants. Nearly all the plants mentioned are in cultivation at College Garden of the West of Scotland Agricultural

College, Kilmarnock, and may be seen by visitors to the Farm. Other herbs used in cookery, and a number of poisonous plants are also grown there.

A more complete catalogue of medicinal plants and their uses will be found in books dealing with this subject, such as :—

"Profitable Herb Growing and Collecting," by Ada B. Teetgen. *Country Life Library*, 1916. 20 Tavistock Street, London, W.C. 3s. 6d. net.

Potter's "Cyclopædia of Botanical Drugs and Preparations," 2nd edit., by R. C. Wren and E. M. Holmes. Potter & Clark, 60-64 Artillery Lane, London, E. 3s. net.

"The British Pharmacopœia," 1914 edition. Constable & Co., London. 10s. 6d. net.

Squire's "Companion to The British Pharmacopœia," 19th edition, 1916. J. & A. Churchill, London. 15s. net.

"The British Pharmaceutical Codex." The Pharmaceutical Society, 72 Great Russell Street, London, W.C.

"Pharmacographia : a History of the Principal Drugs of Vegetable Origin," by Flückiger and Hanbury, 2nd edition. Macmillan & Co., London.
(An exhaustive work on this subject).

"The New Family Herbal and Botanic Physician," by M. Robinson, M.D., coloured plates. Wm. Nicholson & Sons, Halifax. 3s. 6d.

LIST

OF

HARDY HERBS, TREES, AND SHRUBS USED IN MEDICINE.

LIST OF HARDY HERBS, TREES,

* Duration; A = Annual;

Botanical Name.	Common Name.	Natural Order.
Achillea Millefolium	Yarrow, Milfoil	Compositæ
Aconitum Napellus	Aconite, Monkshood, Wolfsbane	Ranunculaceæ
Acorus Calamus	Sweet Flag	Araceæ
Adiantum Capillus-Veneris	Maidenhair Fern	Filices
Adonis vernalis	False Hellebore, Pheasants-eye.	Ranunculaceæ
Adoxa Moschatellina	Moschatel	Caprifoliaceæ
Aesculus Hippocastanum	Horsechestnut	Sapindaceæ
Aethusa Cynapium	Fool's Parsley	Umbelliferæ
Agrimonia Eupatoria	Agrimony, Stickwort	Rosaceæ
Agropyron repens	Couch Grass, Twitch	Gramineæ
Ajuga Chamæpitys	Ground Pine	Labiatæ
,, reptans	Bugle	,,
Alchemilla arvensis	Parsley Piert	Rosaceæ
,, vulgaris	Lady's Mantle	,,
Alisma Plantago	Water Plantain	Alismaceæ
Allium sativum	Garlic	Liliaceæ
Alnus glutinosa	Alder	Cupuliferæ
Althaea officinalis	Marsh Mallow	Malvaceæ
,, rosea	Hollyhock	,,
Amaranthus hypochondriacus	Amaranth, Love-lies-bleeding	Amaranthaceæ
Anacyclus officinarum	German Pellitory	Compositæ
,, Pyrethrum	Pellitory, Spanish Pellitory	,,
Anagallis arvensis	Scarlet Pimpernel	Primulaceæ
Anemone Hepatica	Hepatica	Ranunculaceæ
,, Pulsatilla	Pulsatilla, Pasque Flower	,,
Antennaria dioica	Life Everlasting, Catsfoot	Compositæ
Anthemis Cotula	Mayweed	,,
,, nobilis	Chamomile	,,
Apium graveolens	Wild Celery	Umbelliferæ
Archangelica officinalis	Angelica, Garden Angelica	,,

ND SHRUBS USED IN MEDICINE.

= Biennial; P = Perennial

Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
P.	Whole herb,	August	Sandy and gravelly soils, common.
P.	Root, leaves	Autumn	Moist soil, some shade.
P.	Rhizome	Spring	Marshes.
P.	Whole herb	Summer	Cliffs and caves. Rare.
P.	,, ,,	Spring	Ordinary soil, used in Epilepsy, not British.
P.	,, ,,	Summer	Woods and shady lanes.
P.	Bark, fruit	Autumn	Ordinary soil.
A.	Whole herb	July-Aug.	Cornfields and waste places.
P.	,, ,,	July-Aug.	Meadows and roadsides.
P.	Rhizome	March	Roadsides and waste places.
A.	Leaves	July-Sep.	Gravelly and chalky soils.
P.	Whole herb	Summer	Moist woods.
A.	,, ,,	July-Sep.	Sandy soil, weed of cultivation.
P.	,, ,,	June	Hilly pastures.
P.	Leaves	Summer	Streams and ditches.
P.	Bulb	Autumn-Spring	Ordinary soil, not British.
P.	Bark	Autumn	Damp situations.
P.	Root and leaves	Aug.-Sep.	River banks and marshes.
B.	Flowers	August, 2nd year.	Ordinary soil, not British.
A.	Whole herb	Summer	Ordinary soil, warm district, not British.
P.	Root	Autumn	Ordinary soil.
P.	,,	,,	,, ,,
A.	Leaves	Summer	Heavy soil.
P.	Whole herb	,,	Shady places, not British.
P.	,, ,,	,,	Chalky heaths.
P.	,, ,,	,,	Mountain heaths.
A.	,, ,,	,,	Cornfields.
P.	Flowers and whole herb	,,	Sandy heaths, &c. Double-flowered form is preferred.
B.	Fruit "seed"	When ripe	Salt marshes.
B.	Whole herb, root	Before flowering	Ordinary soil, tender plant.

Botanical Name.	Common Name.	Natural Order.
Arctium majus	Burdock	Compositæ
,, minus	Small Burdock	,,
Arctostaphylos Uva-ursi	Bearberry, Red Bearberry	Ericaceæ
Arnica montana	Arnica	Compositæ
Artemisia Abrotanum	Southernwood	,,
,, Absinthium	Wormwood	,,
,, Dracunculus	Tarragon	,,
,, maritima	Sea Wormwood, Santonin	,,
,, Stœchmanniana	Wormseed	,,
,, vulgaris	Mugwort	,,
Arum maculatum	Cuckoo-pint, Lords and Ladies	Araceæ
Asarum europæum	Asarabacca	Aristolochiaceæ
Asparagus officinalis	Asparagus	Liliaceæ
Asperula odorata	Woodruff	Rubiaceæ
Atropa Belladonna	Belladonna, Deadly Nightshade	Solanaceæ
Ballota nigra	Black Horehound	Lobiatæ
Baptisia tinctoria	Wild Indigo, Indigo Broom	Leguminosæ
Bellis perennis	Daisy	Compositæ
Berberis Aquifolium	Mountain Grape, Holly-leaved Barberry	Berberidaceæ
,, aristata	Berberis	,,
,, vulgaris	Common Barberry	,,
Betula alba	Birch	Cupuliferæ
,, lenta	Cherry Birch	,,
Borago officinalis	Borage	Boraginaceæ
Brassica alba	White Mustard	Cruciferæ
,, nigra	Black Mustard	,,
Bryonia alba	White Bryony	Cucurbitaceæ
,, dioica	Common Bryony	,,

Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
B.	Root, leaves, seeds	July	Woods and roadsides, ordinary soil.
B.	,, ,,	,,	,, ,, ,,
P.	Leaves	Summer	Mountains, peaty soil.
P.	Root, flowers	Root in Autumn, Flowers in Summer	Ordinary soil, not British.
P.	Whole herb	August	Light soil, not British.
P.	,, ,,	May-July	Waste places.
P.	,, ,,	Summer	Light soil, not British.
P.	Unopened flowers	,,	Sandy soil.
P.	Seeds	,,	Light sandy soil, not British.
P.	Whole herb	,,	Ordinary soil, waste places.
P.	Tubers	Autumn-Spring	Ordinary soil, woods and waysides.
P.	Root and herb	Summer	Woods, peaty soil.
P.	Whole herb	,,	Sandy soil, seaside plant.
P.	,, ,,	May	Ordinary soil, woods and shady places.
P.	Root, leaves	June	Limestone soil, woods and waste places, poisonous.
P.	Whole herb	Summer	Ordinary soil, waste places.
P.	Root	Autumn	Light soil, not British, a dye plant.
P.	Whole herb	Spring-Autumn	Ordinary soil, grass fields.
P.	Root	Autumn-Spring	Ordinary soil, not British.
P.	Stem	,,	,, ,, ,,
P.	Root bark, stem bark	,,	Ordinary soil.
P.	Bark and leaves	Late Summer	,, ,,
P.	Bark	Autumn-Winter	,, ,, not British.
A.	Leaves	Summer	,, ,, ,,
A.	Seeds	When ripe	,, ,, a field crop.
A.	,,	,,	,, ,, ,,
P.	Root	Autumn	,, ,, not British.
P.	,,	,,	,, ,, hedgerows and woods.

Botanical Name.	Common Name.	Natural Order.
Calamintha officinalis	Calamint, Mountain Mint	Labiatæ
Calendula officinalis	Pot Marigold	Compositæ
Caltha palustris	Marsh Marigold, King Cup	Ranunculaceæ
Cannabis sativa	Indian Hemp	Urticaceæ
Capsella Bursa-pastoris	Shepherd's Purse	Cruciferæ
Carbenia benedicta	Holy Thistle, Blessed Thistle	Compositæ
Cardamine pratensis	Lady's Smock, Cuckoo Flower	Cruciferæ
Carduus Marianus	Milk Thistle	Compositæ
Carthamus tinctorius	Safflower, American Saffron	,,
Carum Carvi	Caraway	Umbelliferæ
,, copticum	Ajowan Oil Plant	,,
,, Petroselinum	Parsley	,,
Castanea vesca	Spanish Chestnut, Sweet Chestnut	Cupuliferæ
Centaurea Cyanus	Cornflower, Blue Bottle	Compositæ
,, nigra	Knapweed	,,
Chelidonium majus	Greater Celandine	Papaveraceæ
Chenopodium Anthelminticum.	Wormseed, Mexican Tea	Chenopodiaceæ
Chenopodium Vulvaria (C. olidum)	Arrach, Stinking Arrach	,,
Chrysanthemum cinerariæfolium	Dalmatian Insect Powder Plant	Compositæ
Chrysanthemum Leucanthemum	Ox-eye Daisy	,,
Chrysanthemum Parthenium	Feverfew, Featherfew	,,
Cichorium Intybus	Chicory, Succory	,,
Cimicifuga racemosa	Black Cohosh, Black Snake-Root	Ranunculaceæ
Claviceps purpurea	Ergot of Rye	Fungi
Cochlearia Armoraica	Horseradish	Cruciferæ

*Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
P.	Whole herb	Summer	Ordinary soil, waste places.
A.	Whole herb, flowers	August	,, ,, ligulate flowers, not British.
P.	Whole herb, root	Summer	Damp soil, marshes.
A.	Flowering tops	,,	Ordinary soil, flowering tops of pistillate plants, not British.
A.	Whole herb	Spring-Autumn	Waste places and cultivated ground.
A.	,, ,,	Summer	Ordinary soil, not British.
P.	,, ,,	Spring-Summer	Damp meadows.
B.	Root and seeds		Ordinary soil.
A.	Flowers	,,	,, ,, not British.
B.	Fruit	July-Aug.	Waste places, ordinary soil.
B.	,,	,,	,, ,, not British.
B.	Root, fruit	Fruit in Summer, Root in Sept.	Ordinary soil.
P.	Leaves	Summer	Ordinary soil.
A.	Flowers	July	,, ,, waste places.
P.	Root and seeds	Root in Autumn	,, ,, hedgerows, &c.
P.	Whole herb	July	,, ,, shady places.
A.	Fruit, "seeds"	July-Sept.	,, ,, not British.
A.	Whole herb	,,	Sandy soil, seashores.
P.	Flowers	Summer	Ordinary soil, not British.
P.	Whole herb	,,	,, ,, meadows and waste places.
A.	,, ,,	,,	Ordinary soil, waste places.
B.	Root	Autumn-Spring	Chalky soils, waysides.
P.	Rhizome & root	,,	Moist soil, not British.
A.	Fungus	Summer	Parasite on rye.
P.	Fresh Root	March, &c.	Ordinary soil, becomes a troublesome weed.

Botanical Name.	Common Name.	Natural Order.
Cochlearia officinalis	Scurvy-grass	Cruciferæ
Colchicum autumnale	Meadow Saffron, Naked Ladies	Liliaceæ
Conium maculatum	Hemlock, Poison Hemlock	Umbelliferæ
Convallaria majalis	Lily-of-the-Valley	Liliaceæ
Convolvulus sepium	Bindweed	Convolvulaceæ
Coriandrum sativum	Coriander	Umbelliferæ
Cratægus Oxyacantha	Hawthorn, Haw	Rosaceæ
Crocus sativus	Saffron Crocus	Iridaceæ
Cucurbita maxima	Melon Pumpkin Seed	Cucurbitaceæ
Cuminum Cyminum	Cumin	Umbelliferæ
Cuscuta Epithymum	Dodder	Convolvulaceæ
Cynoglossum officinale	Houndstongue	Boraginaceæ
Cytisus scoparius	Broom	Leguminosæ
Daphne Gnidium	Daphne	Thymelaceæ
,, Laureola	Spurge Laurel	,,
,, Mezereum	Mezereon	,,
Datura Stramonium	Thornapple	Solanaceæ
Daucus Carota	Wild Carrot	Umbelliferæ
Delphinium Staphisagria	Stavesacre Seed	Ranunculaceæ
Digitalis purpurea	Foxglove	Scrophulariaceæ
Drosera rotundifolia	Sundew	Droseraceæ
Dryopteris. See 'Lastrea.'		
Echium vulgare	Bugloss, Viper's Bugloss	Boraginaceæ
Equisetum arvense	Horsetail, Pipeweed	Equisetaceæ
Erigeron (Leptilon) canadense	Fleabane, Horseweed	Compositæ
Eryngium campestre	Eryngo	Umbelliferæ
,, maritimum	Sea Holly	,,
Erythræa Centaurium	Centaury	Gentianaceæ
Erythronium americanum	American Adder's Tongue	Liliaceæ

*Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
A.	Whole herb	Spring to Summer	Ordinary soil, salt marshes.
P.	Corms and seeds	Corms early Summer	,, ,, meadows, poisonous.
B.	Leaves, fruits	June-July	Ordinary soil, waste places.
P.	Rhizome, leaves, flowers	May	Chalky woods.
P.	,, ,,	Autumn-Winter	Ordinary soil, troublesome weed.
A.	Fruit "seeds"	Aug.-Sept.	Ordinary soils, not British.
P.		Autumn	Ordinary soil.
P.	Flower pistils	,,	Light soil, not British.
A.	Seed	,,	,, ,, tender plant, not British.
A.	Fruit "seed"	,,	,, ,, ,, ,,
A.	Whole herb	Summer	Parasite on gorse, heather, &c.
B.	Whole herb, root	Autumn-Spring	Ordinary soil, waste places.
P.	Young shoots	May	Gravelly soils.
P.	Dried bark	Autumn	Peaty soil, not British.
P.	Bark	,,	,, ,, woods.
P.	Bark of root and stem	,,	Ordinary soil, woods, &c.
A.	Leaves, seeds	Summer	,, ,, not British.
B.	Whole herb	July	Light soil, heaths and banks.
B.	Seed	When ripe	Ordinary soil, tender, not British.
B.	Leaves	Before flowering	Well-drained loose soil.
P.	Whole herb	Summer	Bogs, on Sphagnum moss.
B.	Whole herb	Summer	Chalky soil, cultivated soil.
P.	,, ,,	,,	Light soil, waste places.
A.	,, ,, seeds	,,	Waste places.
P.	Root	Autumn-Spring	Light sandy soil, near sea.
P.	,,	,,	Seashores.
B.	Whole herb	July	Dry pastures.
P.	Fresh leaves	Spring-Summer	Ordinary soil, not British.

Botanical Name.	Common Name.	Natural Order.
Eupatorium cannabinum	Hemp Agrimony, Holy Rope	Compositæ
,, perfoliatum	Boneset, Indian Sage	,,
,, purpureum	Gravel Root	,,
Euphorbia Peplus	Petty Spurge	Euphorbiaceæ
,, pilulifera	Euphorbia	,,
Euphrasia officinalis	Eyebright	Scrophulariaceæ
Ferula Asafœtida	Asafœtida, Giant Fennel	Umbelliferæ
Fœniculum officinale	Fennel	,,
Fraxinus excelsior	Ash	Oleaceæ
Fumaria officinalis	Fumitory	Fumariaceæ
Galega officinalis	Goat's Rue	Leguminosæ
Galium Aparine	Clivers, Cleavers, Goose-Grass	Rubiaceæ
,, Cruciata	Crosswort	,,
,, verum	Ladies' Bedstraw	,,
Gaultheria procumbens	Wintergreen	Ericaceæ
Genista tinctoria	Dyers' Greenweed	Leguminosæ
Gentiana campestris	English Gentian, Field Gentian	Gentianaceæ
,, lutea	Yellow Gentian, Gentian Root	,,
Geranium maculatum	Cranesbill, Alum-root	Geraniaceæ
Geum urbanum	Wood Avens, Herb Bennet	Rosaceæ
Glechoma. See 'Nepeta.'		
Glycyrrhiza glabra	Spanish Liquorice	Leguminosæ
Gnaphalium obtusifolium (G. polycephalum)	Cudweed	Compositæ
Gnaphalium uliginosum	English Cudweed	,,
Grindelia squarrosa, etc.	Grindelia	,,
Hamamelis virginiana	Witch Hazel	Hamamelidaceæ
Hedera Helix	Ivy	Araliaceæ
Helleborus fœtidus	Setterwort, Stinking Hellebore	Ranunculaceæ
,, niger	Christmas Rose	,,

*Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
P.	Whole herb	Summer	Damp soil, river banks.
P.	,, ,,	,,	Ordinary soil, not British.
P.	Root, rhizome	Autumn	,, ,, ,,
A.	Whole herb	Summer-Autumn	,, ,, common weed.
P.	,, ,,	,,	Not hardy, not British.
A.	,, ,,	Summer	Dry heaths and waste places.
P.	Root, gum, resin	Autumn	Light soil, not British.
B.	Fruit "seeds"	Summer-Autumn	Chalky soil, waste places.
P.	Bark, leaves	,,	Ordinary soil.
A.	Whole herb	,,	Common on cultivated soil.
P.	,, ,,	,,	Ordinary soil, not British.
A.	,, ,,	,,	,, ,, hedgerows, and weed of cultivation.
P.	,, ,,	,,	Shady lanes.
P.	,, ,,	,,	Sandy heaths.
P.	Leaves	,,	Peaty soil, not British.
P.	Whole herb	,,	Thickets, &c.
A.	,, ,, root	,,	Chalky heaths.
P.	Root	Autumn-Spring	,, ,, not British.
P.	Whole herb, root	Spring	Ordinary soil, not British.
P.	,, ,,	,,	Woods and waste places.
P.	Root	Autumn-Spring	Deep sandy soil, not British.
B.	Whole herb	Summer	Ordinary soil, not British.
A.	,, ,,	,,	Sandy heaths.
A.	Leaves and flowering tops	,,	Light soil, not British.
P.	Bark, leaves	Summer-Autumn	Ordinary soil, not British.
P.	Leaves, fruit	Winter	Ordinary soil.
P.	Whole herb	Summer	,, ,,
P.	Rhizome, root	Autumn-Winter	,, ,, not British.

Botanical Name.	Common Name.	Natural Order.
Herniaria glabra	Rupture Wort	Illecebraceæ
Hieracium Pilosella	Mouse Ear	Compositæ
Hydrastis canadensis	Golden Seal, Hydrastis Rhizome	Ranunculaceæ
Hypericum Androsæmum	Tutsan	Hypericaceæ
,, perforatum	St. John's Wort	,,
Humulus Lupulus	Hop	Urticaceæ
Hyoscyamus niger	Henbane	Solanaceæ
Hyssopus officinalis	Hyssop	Labiatæ
Ilex Aquifolium	Holly	Aquifoliaceæ
Inula Helenium	Elecampane	Compositæ
Iris fœtidissima	Gladwin Iris	Iridaceæ
,, florentina	Orris	,,
,, lævigata (I. versicolor)	Japanese Iris, Blue Flag Root	,,
,, Pseudacorus	Yellow Flag, Yellow Iris	,,
Juniperus communis	Juniper, Oil of Juniper	Coniferæ
,, Sabina	Savine	,,
Lactuca virosa	Wild Lettuce	Compositæ
Lamium album	White Archangel, White Deadnettle	Labiatæ
,, Galeobdolon	Yellow Archangel, Yellow Deadnettle	,,
Larix europæa	Larch	Coniferæ
Lastrea Filix-mas	Male Fern	Filices
Laurus nobilis	Sweet Bay	Lauraceæ
Lavendula vera	Lavender	Labiatæ
Ledum latifolium	Labrador Tea, James's Tea	Ericaceæ
Leonurus Cardiaca	Motherwort	Labiatæ
Ligusticum officinale	Lovage	Umbelliferæ
Lilium candidum	Meadow Lily, Madonna Lily	Liliaceæ
Linaria vulgaris	Fluellin, Toadflax	Scrophulariaceæ

*Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
P.	Whole herb	Summer	Sandy seashores.
P.	,, ,,	,,	Dry banks, heaths, &c.
P.	Rhizome & root	Autumn	Moist soil, some shade, not British.
P.	Whole herb	Summer	Ordinary soil, shady roadsides, &c.
P.	,, ,,	,,	,, ,, thickets.
P.	Fruit and flowers	Autumn	,, ,, hedgerows.
A.B.	Leaves	Summer	,, ,, waste places.
P.	Whole herb	,,	,, ,, not British.
P.	Leaves, fruit	Autumn-Winter	,, ,,
P.	Root	March	,, ,, moist meadows.
P.	,,	,,	,, ,, thickets.
P.	Rhizome	Autumn-Spring	,, ,, not British.
P.	,,	,,	Damp soil, not British.
P.		,,	,, ,, marshes.
P.	Green fruit		Chalky downs.
P.	Young shoots	Spring	Ordinary soil, not British.
B.	Whole herb (juice)	Summer	Sandy soil, waste places.
P.	Whole herb	,,	Ordinary soil, waste places.
P.	,, ,,	Summer	,, ,, ,,
P.	Bark	Autumn	,, ,, not British.
P.	Rhizome	Autumn-Spring	,, ,, woods and roadsides.
P.	Leaves, fruit, oil	May-Sept.	Ordinary soil, tender shrub, not British.
P.	Flowers	July-Aug.	Light sandy soil, not British.
P.	Leaves	Summer	Peaty soil, not British.
P.	Whole herb	,,	Light soil, waste places.
P.	Root	March	Ordinary soil, not British.
P.	Bulb	Autumn-Spring	Light soil, not British.
P.	Whole herb	Summer	Light soil, waste places.

Botanical Name.	Common Name.	Natural Order.
Linum catharticum	Mountain Flax, Purging Flax	Linaceæ
,, usitatissimum	Linseed, Flax	,,
Lobelia inflata	Lobelia, Indian Tobacco	Campanulaceæ
Lonicera Caprifolium	Honeysuckle	Caprifoliaceæ
Lycopodium clavatum	Clubmoss	Lycopodiaceæ
Lysimachia vulgaris	Yellow Loosestrife	Primulaceæ
Malva sylvestris	Mallow	Malvaceæ
Marrubium vulgare	Horehound	Labiatæ
Matricaria Chamomilla	German Chamomile	Compositæ
Melilotus arvensis	Field Melilot	Leguminosæ
,, officinalis	Melilot	,,
Melissa officinalis	Balm	Labiatæ
Mentha Piperita	Peppermint, Brandy Mint	,,
,, Pulegium	Pennyroyal	,,
,, sativa	Wild Mint, Marsh Mint	,,
,, sylvestris	Horsemint	,,
,, viridis	Spearmint, Green Mint	,,
Menyanthes trifoliata	Buckbean, Bogbean	Gentianaceæ
Mercurialis perennis	Dog Mercury	Euphorbiaceæ
Morus nigra	Mulberry	Urticaceæ
Myrica cerifera	Bayberry	Myricaceæ
,, Gale	Sweet Gale, Bog Myrtle	,,
Myrrhis odorata	Sweet Cicely	Umbelliferæ
Nepeta Cataria	Catnep, Catnip, Catmint	Labiatæ
,, hederacea (N. Glechoma)	Ground Ivy	,,
Nicotiana Tabacum	Tobacco	Solanaceæ
Ocimum Basilicum	Basil, Sweet Basil	Labiatæ
Oenanthe crocata	Water Dropwort	Umbelliferæ
,, Phellandrium	Water Fennel, Fine-leaved Dropwort	,,
Ophioglossum vulgatum	English Adder's Tongue	Filices
Orchis latifolia	Salep, Broad-leaved Orchis	Orchidaceæ

Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
A.	Whole herb	Summer	Chalky or sandy soil, heaths, banks, &c.
A.	Seed	,,	Ordinary soil, waste places.
A.B.	Whole herb, seed	,,	,, ,, not British.
P.	Flowers, leaves	,,	,, ,, woods.
P.	Whole herb, spores	,,	Moors and damp heaths.
P.	Whole herb	,,	Ordinary soil, river banks.
B.	Whole herb, flowers	,,	Waste places, flowers with calyx attached.
P.	Whole herb	,,	Ordinary soil, hedgerows and waste places.
A.	Flowers	,,	Ordinary soil, waste places.
A.	Whole herb	July	,, ,, fields and waste places.
A.	,, ,,	,,	,, ,, ,,
P.	,, ,,	,,	,, ,, waste places.
P.	,, ,,	August	,, ,, moist situations.
P.	,, ,,	,,	,, ,, ,, ,,
P.	,, ,,	,,	,, ,, ,, ,,
P.	,, ,,	,,	,, ,, waste places.
P.	,, ,,	,,	,, ,, moist situations.
P.	,, ,,	June	Marshes.
P.	,, ,,	April	Woods and waste places.
P.	Fruit for juice	Autumn	Ordinary soil, not British.
P.	Bark	,,	Peaty soil, not British.
P.	Shoots	Summer	,, ,, mountains and bogs.
P.	Whole herb, root	,,	Ordinary soil, waste places.
P.	Whole herb	,,	,, ,, ,, ,,
P.	,, ,,	,,	,, ,, damp and shady places.
A.	Leaves	Autumn	,, ,, tender plant, not British.
A.	Whole herb	Summer	,, ,, ,, ,,
P.	Root	Autumn-Spring	,, ,, marshes, poisonous.
P.	Fruit	,,	,, ,, ditches, ,,
P.	Leaves	Summer	Moist banks and meadows.
P.	Tubers	Autumn-Spring	Moist meadows.

Botanical Name.	Common Name.	Natural Order.
Orchis maculata	Salep, Spotted Orchis	Orchidaceæ
,, mascula	,, Purple Orchis	,,
Origanum marjorana	Sweet Marjoram	Labiatæ
,, vulgare	Wild Marjoram	,,
Oxalis Acetosella	Wood Sorrel	Oxalidaceæ
Pæonia officinalis	Peony, Pæony	Ranunculaceæ
Papaver Rhœas	Field Poppy, Red Poppy Petals, Corn Rose	Papaveraceæ
,, somniferum	Opium Poppy, Maw Seed	,,
Parietaria officinalis	Pellitory of the Wall	Urticaceæ
Paris quadrifolia	Herb Paris	Liliaceæ
Petasites vulgaris	Butterbur	Compositæ
Peucedanum graveolens	Dill	Umbelliferæ
,, Ostruthium	Masterwort	,,
Phytolacca decandra	Pokeroot	Phytolaccaceæ
Picrorhiza Kurroa	Picrorhiza	Scrophulariaceæ
Pimpinella Anisum	Aniseed, Anise, Anisum Fruit	Umbelliferæ
,, Saxifraga	Burnet Saxifrage	,,
Plantago major	Plantain, Broad-leaved Plantain	Plantaginaceæ
,, ovata	Ispaghula	,,
,, Psyllium	Flea Seed	,,
Podophyllum Emodi	Indian Podophyllin Rhizome	Berberidaceæ
,, peltatum	American Mandrake, Podophyllin, May Apple	,,
Polemonium reptans	Sweatroot, Abscess Root	Polemoniaceæ
Polygonatum multiflorum	Solomon's Seal	Liliaceæ
Polygonum aviculare	Knot-grass	Polygonaceæ
,, Bistorta	Bistort, Snakeweed	,,
,, erectum	Russian Knot-grass	,,
,, Hydropiper	Smartweed	,,
Polypodium vulgare	Polypody Root	Filices
Populus tremuloides	White Poplar, American Aspen	Salicaceæ
Potentilla Anserina	Silverweed	Rosaceæ
,, Tormentilla	Tormentil	,,

Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
P.	Tubers	Autumn-Spring	Moist pastures, roadsides.
P.	,,	,,	,, woods.
P.	Whole herb	Summer	Ordinary soil, not British.
P.	,, ,,	,,	,, ,, dry heaths, &c.
P.	,, ,,	,,	Woods.
P.	Root	Autumn-Spring	Ordinary soil, not British.
A.	Petals	Summer	Cornfields and waste places.
A.	Fruits, flowers	,,	Rich, moist soil, sunny position.
P.	Whole herb	,,	Walls and dry places, sandy soil.
P.	,, ,,	,,	Damp woods. Rare.
P.	Rhizome	April	Ordinary soils, ditches, &c.
A.	Fruit "seeds"	Summer	,, ,, not British.
P.	Root	Autumn-Spring	,, ,, moist meadows.
P.	Root, fruit	,,	,, ,, not British.
P.	Rhizome	,,	,, ,, ,, ,,
A.	Fruit "seeds"	,,	,, ,, ,, ,,
P.	Whole herb, root	July	,, ,, dry pastures.
P.	Leaves	Summer	Roadsides and waste places.
A.	Seed	Autumn	Ordinary soil, not British.
A.	,,	,,	,, ,, ,, ,,
P.	Rhizome & root	Autumn-Spring	Moist soils, not British.
P.	,, ,,	,,	,, ,, ,,
P.	Rhizome	,,	Ordinary soil, not British.
P.	,,	,,	,, ,, ,,
A.	Whole herb	Summer	,, ,, waste places.
P.	Root	,,	,, ,, moist meadows.
A.	Whole herb	,,	,, ,, not British.
A.	,, ,,	,,	Moist places.
P.	Rhizome and fronds	Summer-Autumn	Tree trunks, walls, and banks.
P.	Bark	Autumn	Ordinary soil, not British.
P.	Whole herb	Summer	,, ,, roadsides.
P.	,, ,, root	Spring	,, ,, heaths.

Botanical Name.	Common Name.	Natural Order.
Poterium officinale	Greater Burnet, Garden Burnet	Rosaceæ
Primula veris	Cowslip, Paigle	Primulaceæ
,, vulgaris	Primrose	,,
Prunella vulgaris	Self-heal	Labiatæ
Prunus Laurocerasus	Cherry-laurel	Rosaceæ
,, Persica	Peach	,,
Pyrus Aucuparia	Mountain Ash, Rowan Tree	,,
,, Cydonia	Quince	,,
Quercus Robur	Oak	Cupuliferæ
Ranunculus Ficaria	Pilewort, Lesser Celandine	Ranunculaceæ
,, Sceleratus	Celery-leaved Buttercup	,,
Rhamnus cathartica	Buckthorn	Rhamnaceæ
,, Frangula	Buckthorn Alder, Black Alder	,,
,, Purshiana	Cascara Sagrada, Sacred Bark	,,
Rheum officinale	Turkey Rhubarb	Polygonaceæ
,, Rhaponticum, &c.	English Rhubarb	,,
Ricinus communis	Castor Oil Plant	Euphorbiaceæ
Rosa canina	Dog Rose	Rosaceæ
,, centifolia	Pale Rose, Cabbage Rose	,,
,, damascena	Damask Rose, Rose Water	,,
,, gallica	Red Rose	,,
Rosmarinus officinalis	Rosemary	Labiatæ
Rubia tinctoria	Madder, Dyer's Madder	Rubiaceæ
Rubus Idæus	Raspberry	Rosaceæ
Rumex aquaticus	Water Dock, Red Dock	Polygonaceæ
,, crispus	Yellow Dock, Curly Dock	,,
,, obtusifolius	Common Dock	,,
Ruscus aculeatus	Butcher's Broom	Liliaceæ
Ruta graveolens	Rue	Rutaceæ

*Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
P.	Whole herb	Summer	Ordinary soil, meadows.
P.	Flowers	April-May	Chalky pastures.
P.	Whole herb	Spring	Woods and shady places.
P.	,, ,,	Summer	Damp places.
P.	Leaves	Summer	Ordinary soil, not British.
P.	Bark, leaves	Summer-Autumn	,, ,, ,,
P.	Bark, fruit	Autumn	Ordinary soil.
P.	Seed	,,	Ordinary soil, not British.
P.	Bark	,,	Ordinary soil.
P.	Whole herb	Spring	,, ,, moist places.
A.	,, ,,	Summer	Moist soil, marshes.
P.	Berries	Autumn	Ordinary soil, thickets.
P.	Bark	,,	Moist soil, moors.
P.	,,	,,	Ordinary soil, not British.
P.	Root	Autumn-Spring	,, ,, ,,
P.	,,	,,	,, ,, ,,
A.	Seed	,,	,, ,, tender, not British.
P.	Fruit	,,	,, ,, hedgerows.
P.	Petals	Summer	Ordinary soil, not British.
P.	,,	,,	,, ,, ,,
P.	,,	,,	,, ,,
P.	Flowering tops	,,	Light soil, sunny position, not British.
P.	Root	Autumn-Spring	Ordinary soil, not British.
P.	Leaves, fruit	Summer	,, ,, waste places.
P.	Root	Spring	,, ,, ditches.
P.	,,	,,	,, ,, fields and waste places.
P.	,,	,,	,, ,, ,,
P.	Rhizome	Autumn-Spring	,, ,, woods.
P.	Whole herb	Summer	,, ,, not British.

Botanical Name.	Common Name.	Natural Order.
Salix alba	White Willow	Salicaceæ
,, nigra	Black Willow	,,
Salvia officinalis	Sage, Red Sage	Labiatæ
,, Sclarea	Clary	,,
Sambucus Ebulus	Dwarf Elder, Danewort	Caprifoliaceæ
,, nigra	Elder, Bourtree	,,
Sanguinaria canadensis	Bloodroot	Papaveraceæ
Sanguisorba. See 'Poterium.'		
Sanicula europæa	Sanicle	Umbelliferæ
Saponaria officinalis	Soapwort	Caryophyllaceæ
Satureia montana	Savory	Labiatæ
Scabiosa Succisa	Devil's Bit, Scabious	Dipsaceæ
Scolopendrium vulgare	Hart's Tongue Fern	Filices
Scopolia carniolica	Scopolia	Solanaceæ
Scrophularia aquatica	Water Betony	Scrophulariaceæ
,, nodosa	Figwort	,,
Scutellaria lateriflora	Scutellaria, Skullcap	Labiatæ
Sempervivum tectorum	Houseleek	Crassulaceæ
Senecio Jacobæa	Ragwort	Compositæ
,, vulgaris	Groundsel	,,
Sisymbrium officinale	Hedge Mustard	Cruciferæ
Solanum Dulcamara	Bittersweet, Woody Nightshade	Solanaceæ
,, nigrum	Garden Nightshade	,,
Solidago Virgaurea	Golden Rod	Compositæ
Spiræa Ulmaria	Meadow Sweet	Rosaceæ
Stachys Betonica	Wood Betony	Labiatæ
,, palustris	Woundwort, Marsh Woundwort	,,
,, sylvatica	Clownswort, Woundwort	,,

*Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
P.	Bark	Autumn	Ordinary soil.
P.	,,	,,	,, ,,
P.	Leaves	Summer	,, ,, not British.
B.	Whole herb	,,	,, ,, ,,
P.	Leaves	,,	,, ,, waste places.
P.	Bark, leaves flowers, fruit	,,	,, ,, hedgerows and thickets.
P.	Rhizome	When leaves die down	,, ,, not British.
P.	Whole herb	June	Woods and shady places.
P.	Leaves, root	Summer-Autumn	Ordinary soil, hedges and waysides.
P.	Whole herb	Summer	Ordinary soil, not British.
P.	,, ,,	,,	Damp soil, marshes, &c.
P.	,, ,,	,,	Limestone soil, walls and hedgerows.
P.	Rhizome	Autumn-Spring	Ordinary soil, not British.
P.	Whole herb	Summer	,, ,, marshes.
P.	,, ,,	,,	,, ,, moist places.
P.	,, ,,	,,	,, ,, not British.
P.	Fresh leaves	All the year	Light soil, roofs, &c.
P.	Whole herb	Summer	Light soil, common weed, pastures.
A.	,, ,,	Spring-Autumn	Ordinary soil, common weed of cultivation.
A.	,, ,,	Summer	Ordinary soil, hedgerows.
P.	Young twigs	Autumn	,, ,, ,,
A.	Whole herb	Summer	,, ,, waste places.
P.	Leaves	,,	,, ,, thickets and heaths.
P.	Whole herb	,,	,, ,, damp places.
P.	,, ,,	,,	,, ,, woods and hedgerows.
P.	,, ,,	,,	Heavy soil, moist places.
P.	,, ,,	,,	Light soil, woods and waste places.

Botanical Name.	Common Name.	Natural Order.
Stellaria media	Chickweed	Caryophyllaceæ
Swertia Chirata	Chiretta, Chirata	Gentianaceæ
Symphytum officinale	Comfrey, Knitbone	Boraginaceæ
Tamus communis	Black Bryony	Dioscoreaceæ
Tanacetum vulgare	Tansy	Compositæ
Taraxacum officinale	Dandelion	,,
Teucrium Chamædrys	Germander	Labiatæ
,, Scordium	Woodsage	,,
,, Scorodonia	Water Germander	,,
Thymus citriodorus	Lemon Thyme	,,
,, Serpyllum	Wild Thyme	,,
,, vulgaris	Garden Thyme, Thymol	,,
Tilia europæa	Lime Tree	Tiliaceæ
Trifolium pratense	Red Clover	Leguminosæ
Trigonella Foenum-græcum	Fenugreek	,,
Triticum repens. See 'Agropyron.'		
Tussilago Farfara	Coltsfoot	
Ulmus campestris	Elm	Urticaceæ
Urtica dioica	Stinging Nettle	,,
Valeriana officinalis	Valerian, All-heal	Valerianaceæ
,, Wallichii	Indian Valerian	,,
Veratrum viride	American Hellebore	Liliaceæ
Verbascum Thapsus	Mullein	Scrophulariaceæ
Verbena officinalis	Vervain	Verbenaceæ
Veronica Beccabunga	Brooklime, Water Pimpernel	Scrophulariaceæ

*Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
A.	Whole herb	Spring-Autumn	Common weed on cultivated land.
B.	,, ,,	Summer	Ordinary soil, not British (N. Indian plant).
P.	Root, leaves	Leaves in May, Roots in July	Ordinary soil, river banks and waste places.
P.	Root	Spring	Heavy soil, hedgerows and thickets.
P.	Whole herb	August	Ordinary soil, waste places.
P.	Root	Autumn	,, ,, waste places, meadows.
P.	Whole herb	Summer	,, ,, old walls, &c.
P.	,, ,,	,,	,, ,, heaths and hedgerows.
P.	,, ,,	,,	,, ,, wet meadows, ditches.
P.	,, ,,	,,	,, ,, tender plant, not British.
P.	,, ,,	,,	,, ,, heaths.
P.	,, ,,	,,	,, ,, not British.
P.	Flowers with the bract	July	Ordinary soil.
P.	Flowers	Summer	,, ,, waste places and cultivated
A.	Seeds	Autumn	,, ,, not British.
P.	Leaves	February	Heavy soil, waste places.
P.	Bark	Autumn-Winter	Ordinary soil.
P.	Flowers, leaves, seeds	Spring-Autumn	,, ,, waste places.
P.	Rhizome	Autumn	Moist soil, marshes and ditches.
P.	,, and root	,,	,, ,, not British.
P.	,, ,, ,,	Autumn Spring	,, ,, ,, ,, poisonous.
B.	Leaves, flowers, root	Summer	Light soil, chalky banks.
P.	Whole herb	,,	Light soil, dry heaths.
P.	,, ,,	,,	Damp soil, ditches.

Botanical Name.	Common Name.	Natural Order.
Veronica officinalis	Speedwell	Scrophulariaceæ
,, virginica	Leptandra, Culvers Root	,,
Viburnum Opulus	Cramp Bark, Guelder Rose	Caprifoliaceæ
,, prunifolium	Black Haw	,,
Vinca major	Large Periwinkle	Apocynaceæ
,, minor	Small Periwinkle	,,
Viola odorata	Violet	Violaceæ
,, tricolor	Heartsease, Wild Pansy	,,
Viscum album	Mistletoe	Loranthaceæ

*Duration.	Part Used.	When to Collect.	Soil, Situation, and Remarks.
P.	Whole herb	Summer	Walls and dry banks.
P.	Rhizome & root	Autumn Spring	Ordinary soil, not British.
P.	Bark	Autumn-Winter	Chalky soil, thickets.
P.	,,	,,	Ordinary soil, not British.
P.	Whole herb	Summer	,, ,, woods and thickets.
P.	,, ,,	,,	,, ,, ,,
P.	Leaves, flowers	,,	,, ,, woods and shady places.
A.	Whole herb	,,	,, ,, weed on cultivated land.
P.	Leaves	,,	Parasite on apple and thorn trees.

COMMON AND BOTANICAL NAMES OF MEDICINAL PLANTS.

ABSCESS-ROOT. *Polemonium reptans.*
ACONITE. *Aconitum Napellus.*
ADDER'S - TONGUE. *Ophioglossum vulgatum.*
ADDER'S - TONGUE, AMERICAN. *Erythronium americanum.*
AGRIMONY. *Agrimonia Eupatoria.*
AJOWAN OIL PLANT. *Carum copticum.*
ALDER. *Alnus glutinosa.*
ALDER BUCKTHORN. *Rhamnus Frangula.*
ALL-HEAL. *Valeriana officinalis.*
ALUM ROOT. *Geranium maculatum.*
AMARANTH. *Amaranthus.*
AMERICAN ADDER'S - TONGUE. *Erythronium americanum.*
AMERICAN HELLEBORE. *Veratrum.*
AMERICAN MANDRAKE. *Podophyllum.*
AMERICAN SAFFRON. *Carthamus tinctorius.*
ANGELICA. *Archangelica officinalis.*
ANISEED. *Pimpinella Anisum.*
ARCHANGEL. *Lamium.*
ARNICA. *Arnica montana.*
ARRACH. *Chenopodium.*
ASAFŒTIDA. *Ferula Asafœtida.*
ASARABACCA. *Asarum europæum.*
ASH. *Fraxinus excelsior.*
ASPARAGUS. *Asparagus officinalis.*
ASPEN. *Populus.*
AVENS. *Geum.*

BALM. *Melissa officinalis.*
BARBERRY. *Berberis vulgaris.*
BASIL. *Ocimum Basilicum.*
BAYBERRY. *Myrica cerifera.*
BEAR - BERRY. *Arctostaphylos Uva-ursi.*
BELLADONNA. *Atropa Belladonna.*
BERBERIS. *Berberis aristata.*
BETONY. *Stachys Betonica.*
BINDWEED. *Convolvulus.*
BIRCH. *Betula.*
BISTORT. *Polygonum Bistorta.*
BITTER-SWEET. *Solanum Dulcamara.*
BLACK BRYONY. *Tamus communis.*
BLACK COHOSH. *Cimicifuga racemosa.*
BLACK HAW. *Viburnum prunifolium.*
BLACK HOREHOUND. *Ballota nigra.*
BLACK MUSTARD. *Brassica nigra.*
BLACK SNAKE ROOT. *Cimicifuga racemosa.*
BLESSED THISTLE. *Carbenia benedicta.*
BLOODROOT. *Sanguinaria.*
BLUE-BOTTLE. *Centaurea Cyanus.*
BLUE-FLAG. *Iris lævigata.*
BOG BEAN. *Menyanthes trifoliata.*
BOG MYRTLE. *Myrica Gale.*
BONESET. *Eupatorium perfoliatum.*
BORAGE. *Borago officinalis.*
BOURTREE. *Sambucus nigra.*
BROOKLIME. *Veronica Beccabunga.*
BROOM. *Cytisus scoparius.*
BRYONY. *Bryonia.*
BUCKBEAN. *Menyanthes trifoliata.*
BUCKTHORN. *Rhamnus.*
BUGLE. *Ajuga reptans.*
BUGLOSS. *Echium vulgare.*
BURDOCK. *Arctium.*
BURNET. *Poterium.*
BURNET SAXIFRAGE. *Pimpinella.*
BUTCHER'S BROOM. *Ruscus aculeatus.*
BUTTER-BUR. *Petasites vulgaris.*
BUTTERCUP. *Ranunculus.*

CALAMINT. *Calamintha officinalis.*
CARAWAY. *Carum Carvi.*
CARROT. *Daucus Carota.*
CASCARA. *Rhamnus Purshiana.*
CASTOR OIL. *Ricinus communis.*
CAT-MINT. *Nepeta Cataria.*
CATNEP, CATNIP. *Nepeta Cataria.*

Cat's-Foot. *Antennaria dioica.*
Celandine, Greater. *Chelidonium majus.*
Celandine, Lesser. *Ranunculus Ficaria.*
Celery. *Apium graveolens.*
Centaury. *Erythræa Centaurium.*
Chamomile. *Anthemis nobilis.*
Cherry Birch. *Betula lenta.*
Cherry Laurel. *Prunus Laurocerasus.*
Chestnut. *Castanea vesca.*
Chickweed. *Stellaria media.*
Chicory. *Cichorium Intybus.*
Chiretta (Chirata). *Swertia Chirata.*
Christmas Rose. *Helleborus niger.*
Cicely. *Myrrhis odorata.*
Clary. *Salvia Sclarea.*
Cleavers. *Galium Aparine.*
Clivers. *Galium Aparine.*
Clover. *Trifolium pratense.*
Clownswort. *Stachys sylvatica.*
Club-Moss. *Lycopodium clavatum.*
Colt's-Foot. *Tussilago Farfara.*
Comfrey. *Symphytum officinalis.*
Common Bryony. *Bryonia dioica.*
Cornflower. *Centaurea Cyanus.*
Coriander. *Coriandrum sativum.*
Couch-grass. *Agropyron repens.*
Cowslip. *Primula veris.*
Cramp Bark. *Viburnum Opulus.*
Crane's-Bill. *Geranium.*
Crosswort. *Galium Cruciata.*
Cuckoo-Flower. *Cardamine pratensis.*
Cuckoo-Pint. *Arum maculatum.*
Cudweed. *Gnaphalium.*
Culver's Root. *Veronica virginica.*
Cumin. *Cuminum Cyminum.*

DAISY. *Bellis perennis.*
Dalmatian Insect-Powder-Plant. *Chrysanthemum cinerariæfolium.*
Dandelion. *Taraxacum officinale.*
Danewort. *Sambucus Ebulus.*
Daphne. *Daphne Gnidium.*
Dead-Nettle. *Lamium.*
Deadly Night-Shade. *Atropa Belladonna.*
Devil's Bit. *Scabiosa Succisa.*
Dill. *Peucedanum graveolens.*
Dock. *Rumex.*
Dodder. *Cuscuta.*
Dog Mercury. *Mercurialis perennis.*
Dyer's Greenweed. *Genista tinctoria.*

ELDER. *Sambucus nigra.*
Elecampane. *Inula Helenium.*
Elm. *Ulmus.*
English Adder's-Tongue. *Ophioglossum.*
English Cudweed. *Gnaphalium.*
English Gentian. *Gentiana campestris.*
Ergot. *Claviceps purpurea.*
Eryngo. *Eryngium.*
Euphorbia. *Euphorbia pilulifera.*
Eye-Bright. *Euphrasia officinalis.*

FALSE HELLEBORE. *Adonis vernalis.*
Featherfew. *Chrysanthemum Parthenium.*
Fenugreek. *Trigonella Fœnum-græcum.*
Feverfew. *Chrysanthemum Parthenium.*
Field Gentian. *Gentiana campestris.*
Figwort. *Scrophularia nodosa.*
Flag. *Iris.*
Flax. *Linum.*
Flea-Bane. *Erigeron.*
Flea-Seed. *Plantago Psyllium.*
Fluellin. *Linaria vulgaris.*
Fool's Parsley. *Æthusa Cynapium.*
Foxglove. *Digitalis purpurea.*
Fumitory. *Fumaria.*

GARDEN ANGELICA. *Archangelica officinalis.*
Garlic. *Allium sativum.*
Gentian Root. *Gentiana lutea.*
German Chamomile. *Matricaria Chamomilla.*

GERMANDER. *Teucrium Chamædrys.*
GERMAN PELLITORY. *Anacyclus officinarum.*
GIANT FENNEL. *Ferula Asafœtida.*
GLADWIN IRIS. *Iris fœtidissima.*
GOAT'S RUE. *Galega officinalis.*
GOLDEN ROD. *Solidago Virgaurea.*
GOLDEN SEAL. *Hydrastis canadensis.*
GOOSE-GRASS. *Galium Aparine.*
GRAVEL ROOT. *Eupatorium purpureum.*
GREATER CELANDINE. *Chelidonium majus.*
GRINDELIA. *Grindelia squarrosa, &c.*
GROUND-IVY. *Nepeta Glechoma.*
GROUND-PINE. *Ajuga Chamæpitys.*
GROUNDSEL. *Senecio vulgaris.*
GUELDER-ROSE. *Viburnum Opulus.*

HART'S-TONGUE. *Scolopendrium vulgare.*
HAW, HAWTHORN. *Cratægus Oxyacantha.*
HEART'S-EASE. *Viola tricolor.*
HEDGE-MUSTARD. *Sisymbrium officinale.*
HEMLOCK. *Conium maculatum.*
HEMP. *Cannabis sativa.*
HEMP-AGRIMONY. *Eupatorium cannabinum.*
HENBANE. *Hyoscyamus niger.*
HEPATICA. *Anemone Hepatica.*
HERB PARIS. *Paris quadrifolia.*
HOLLY. *Ilex Aquifolium.*
HOLLYHOCK. *Althæa rosea.*
HOLLY-LEAVED BARBERRY. *Berberis Aquifolium.*
HOLY-ROPE. *Eupatorium cannabinum.*
HOLY-THISTLE. *Carbenia benedicta.*
HONEYSUCKLE. *Lonicera.*
HOP. *Humulus Lupulus.*
HOREHOUND. *Ballota nigra.*
HOREHOUND. *Marrubium vulgare.*
HORSE-CHESTNUT. *Æsculus Hippocastanum.*
HORSE-MINT. *Mentha.*
HORSE-RADISH. *Cochlearia Armoracia.*
HORSETAIL. *Equisetum.*
HORSE WEED. *Erigeron canadense.*
HOUND'S-TONGUE. *Cynoglossum officinale.*
HOUSELEEK. *Sempervivum tectorum.*
HYSSOP. *Hyssopus officinalis.*

INDIAN HEMP. *Cannabis sativa.*
INDIAN SAGE. *Eupatorium perfoliatum.*
INDIAN TOBACCO. *Lobelia inflata.*
INDIAN VALERIAN. *Valeriana Wallichii.*
INDIGO BROOM. *Baptisia tinctoria.*
ISPAGHULA, ISPAGHUL. *Plantago ovata.*
IVY. *Hedera Helix.*

JAMES'S TEA. *Ledum latifolium.*
JAPANESE IRIS. *Iris lævigata.*
JUNIPER. *Juniperus communis.*

KING CUP. *Caltha palustris.*
KNAPWEED. *Centaurea nigra.*
KNITBONE. *Symphytum officinale.*
KNOT-GRASS. *Polygonum.*

LABRADOR TEA. *Ledum latifolium.*
LADY'S BED-STRAW. *Galium verum.*
LADY'S MANTLE. *Alchemilla vulgaris.*
LADY'S SMOCK. *Cardamine pratensis.*
LARCH. *Larix europœa.*
LAVENDER. *Lavendula vera.*
LEPTANDRA. *Veronica virginica.*
LETTUCE. *Lactuca.*
LIFE EVERLASTING. *Antennaria dioica.*
LILY OF THE VALLEY. *Convallaria majalis.*
LIME TREE. *Tilia.*
LINSEED. *Linum usitatissimum.*
LIQUORICE. *Glycyrrhiza glabra.*
LOOSE-STRIFE. *Lysimachia vulgaris.*
LORDS AND LADIES. *Arum maculatum.*
LOVAGE. *Ligusticum officinale.*
LOVE-LIES-BLEEDING. *Amaranthus.*

MADDER. *Rubia tinctoria.*
MADONNA LILY. *Lilium candidum.*

MAIDEN-HAIR. *Adiantum Capillus-Veneris.*
MALE-FERN. *Lastrea Felix-mas.*
MALLOW. *Malva.*
MARIGOLD. *Calendula officinalis.*
MARJORAM. *Origanum.*
MARSH MALLOW. *Althæa officinalis.*
MARSH MARIGOLD. *Caltha palustris.*
MASTER-WORT. *Peucedanum Ostruthium.*
MAW SEED. *Papaver somniferum.*
MAY APPLE. *Podophyllum.*
MAYWEED. *Anthemis Cotula.*
MEADOW LILY. *Lilium candidum.*
MEADOW SAFFRON. *Colchicum autumnale.*
MEADOW-SWEET. *Spiræa Ulmaria.*
MELILOT. *Melilotus.*
MELON-PUMPKIN SEED. *Cucurbita maxima.*
MERCURY. *Mercurialis perennis.*
MEXICAN TEA. *Chenopodium.*
MEZEREON. *Daphne Mezereum*
MILFOIL. *Achillea Millefolium.*
MILK THISTLE. *Carduus Marianus* (*Silybum*).
MINT. *Mentha.*
MISTLETOE. *Viscum album.*
MONK'S-HOOD. *Aconitum Napellus.*
MOSCHATEL. *Adoxa Moschatellina.*
MOTHERWORT. *Leonurus Cardiaca.*
MOUNTAIN ASH. *Pyrus Aucuparia.*
MOUNTAIN FLAX. *Linum catharticum.*
MOUNTAIN GRAPE. *Berberis Aquifolium.*
MOUNTAIN MINT. *Calamintha officinalis.*
MOUSE EAR. *Hieracium Pilosella.*
MUGWORT. *Artemisia vulgaris.*
MULBERRY. *Morus nigra.*
MULLEIN. *Verbascum.*
MUSTARD. *Brassica.*
MYRTLE, BOG. *Myrica Gale.*

NAKED LADIES. *Colchicum autumnale.*
NETTLE. *Urtica.*
NIGHTSHADE. *Solanum.*

OAK. *Quercus.*
OPIUM POPPY. *Papaver somniferum.*
ORCHID. *Orchis.*
ORRIS ROOT. *Iris florentina, &c.*
OX-EYE DAISY. *Chrysanthemum Leucanthemum.*

PÆONY. *Pœonia officinalis.*
PAIGLE. *Primula veris.*
PANSY. *Viola.*
PARSLEY. *Carum.*
PARSLEY-PIERT. *Alchemilla arvensis.*
PASQUE-FLOWER. *Anemone Pulsatilla.*
PEACH. *Prunus Persica.*
PELLITORY. *Anacyclus Pyrethrum.*
PSLLITORY-OF-THE-WALL. *Parietaria officinalis.*
PENNY-ROYAL. *Mentha Pulegium.*
PEPPERMINT. *Mentha Piperita.*
PERIWINKLE. *Vinca.*
PETTY SPURGE. *Euphorbia Peplus.*
PHEASANT'S EYE. *Adonis vernalis.*
PILE-WORT. *Ranunculus Ficaria.*
PIMPERNEL. *Anagallis arvensis.*
PIPEWEED. *Equisetum.*
PLANTAIN. *Plantago.*
PODOPHYLLIN. *Podophyllum.*
POISON HEMLOCK. *Conium maculatum.*
POKEROOT. *Phytolacca.*
POLYPODY. *Polypodium vulgare.*
POPLAR. *Populus.*
POPPY. *Papaver.*
PRIMROSE. *Primula.*
PULSATILLA. *Anemone Pulsatilla.*
PURGING FLAX. *Linum catharticum.*

QUINCE. *Pyrus Cydonia* (*Cydonia vulgaris*).

RAGWORT. *Senecio Jacobœa.*
RASPBERRY. *Rubus Idæus.*
RED BEAR-BERRY. *Arctostaphylos Uva-ursi.*
RHUBARB. *Rheum.*
ROSE. *Rosa.*
ROSEMARY. *Rosmarinus officinalis.*

ROWAN-TREE. *Pyrus Aucuparia.*
RUE. *Ruta graveolens.*
RUPTURE-WORT. *Herniaria glabra.*

SACRED BARK. *Rhamnus Purshiana.*
SAFFLOWER. *Carthamus tinctorius.*
SAFFRON CROCUS. *Crocus sativus.*
SAGE. *Salvia.*
SALEP. *Orchis.*
SANICLE. *Sanicula europæa.*
SANTONIN. *Artemisia maritima.*
SAVINE. *Juniperus Sabina.*
SAVORY. *Satureia.*
SCABIOUS. *Scabiosa.*
SCARLET PIMPERNEL. *Anagallis arvensis.*
SCOPOLIA. *Scopolia.*
SKULL-CAP. *Scutellaria.*
SCURVY-GRASS. *Cochlearia officinalis.*
SEA HOLLY. *Eryngium maritimum.*
SEA WORMWOOD. *Artemisia maritima.*
SELF-HEAL. *Prunella vulgaris.*
SETTER-WORT. *Helleborus fœtidus.*
SHEPHERD'S-PURSE. *Capsella Bursa-Pastoris.*
SILVER-WEED. *Potentilla Anserina.*
SMARTWEED. *Polygonum Hydropiper.*
SNAKE-WEED. *Polygonum Bistorta.*
SOAP-WORT. *Saponaria officinalis.*
SOLOMON'S SEAL. *Polygonatum.*
SOUTHERNWOOD. *Artemisia Abrotanum.*
SPANISH CHESTNUT. *Castanea vesca.*
SPANISH LIQUORICE. *Glycyrrhiza glabra.*
SPANISH PELLITORY. *Anacyclus Pyrethrum.*
SPEARMINT. *Mentha viridis.*
SPEEDWELL. *Veronica.*
SPURGE LAUREL. *Daphne Laureola.*
STAVESACRE SEED. *Delphinium Staphisagria.*
STICKWORT. *Agrimonia Eupatoria.*
STINGING NETTLE. *Urtica dioica.*
STINKING ARRACH. *Chenopodium Vulvaria.*
STINKING HELLEBORE. *Helleborus fœtidus.*
ST. JOHN'S WORT. *Hypericum.*
SUCCORY. *Cichorium Intybus.*
SUNDEW. *Drosera.*
SWEAT ROOT. *Polemonium reptans.*
SWEET-BAY. *Laurus nobilis.*
SWEET-CHESTNUT. *Castanea vesca.*
SWEET CICELY. *Myrrhis odorata.*
SWEET-FLAG. *Acorus Calamus.*
SWEET GALE. *Myrica Gale.*

TANSY. *Tanacetum vulgare.*
TARRAGON. *Artemisia Dracunculus.*
THORN-APPLE. *Datura Stramonium.*
THYME. *Thymus.*
THYMOL. *Thymus.*
TOAD-FLAX. *Linaria.*
TOBACCO. *Nicotiana Tabacum.*
TORMENTIL. *Potentilla.*
TUTSAN. *Hypericum Androsæmum.*
TWITCH. *Agropyron repens.*

VALERIAN. *Valeriana.*
VERVAIN. *Verbena officinalis.*
VIOLET. *Viola odorata.*
VIPER'S-BUGLOSS. *Echium vulgare.*

WATER BETONY. *Scrophularia aquatica.*
WATER DROPWORT. *Œnanthe.*
WATER GERMANDER. *Teucrium.*
WATER PIMPERNEL. *Veronica Beccabunga.*
WATER PLANTAIN. *Alisma Plantago.*
WHITE ARCHANGEL. *Lamium album.*
WHITE BRYONY. *Bryonia alba.*
WHITE DEADNETTLE. *Lamium album.*
WHITE MUSTARD. *Brassica alba.*
WILD INDIGO. *Baptisia tinctoria.*
WILLOW. *Salix.*
WINTER - GREEN. *Gaultheria procumbens.*
WITCH HAZEL. *Hamamelis virginiana.*
WOLF'S BANE. *Aconitum Napellus.*
WOOD AVENS. *Geum urbanum.*
WOODRUFF. *Asperula odorata.*

WOOD SAGE. *Teucrium Scorodonia.*
WOOD SORREL. *Oxalis Acetosella.*
WORM-SEED. *Artemisia Stœchmanniana.*
WORM-SEED. *Chenopodium Anthelminticum.*
WORMWOOD. *Artemisia.*
WOUNDWORT. *Stachys.*

YARROW. *Achillea Millefolium.*
YELLOW FLAG. *Iris Pseudacorus.*
YELLOW GENTIAN. *Gentiana lutea.*
YELLOW LOOSE-STRIFE. *Lysimachia vulgaris.*

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FOOD PRODUCTION

IN

COTTAGE AND ALLOTMENT GARDENS

(A REPRINT OF PARTS OF BULLETIN 72, WITH A FEW ADDITIONS)

BY

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FOOD PRODUCTION IN COTTAGE AND ALLOTMENT GARDENS.

INTRODUCTORY.

The following notes are prepared in response to numerous requests for definite information on how to make the best use of our gardens during the abnormal conditions created by the present war. All who possess gardens should endeavour to cultivate them to the fullest extent, and thus produce as much as possible of the most serviceable kinds of garden crops, not only on economic grounds, but also as a means of conserving our national resources. In any scheme of planting, the growers should bear in mind the vagaries of the climate and the kind of soil to be dealt with.

Gardens attached to cottages are not all equally adapted for the production of garden produce, as they vary very much regarding size, aspect, and kind of soil. Some cottage gardens are too small to be of much service in the production of fruit and vegetables; but with a good-sized plot, ranging from five to twenty poles, it is possible to grow a good deal of useful produce.

ALLOTMENT GARDENS.

The term "allotment" is applied to a small plot of land rented to cottagers or to artizans of towns and cities, who have other regular work, and cultivate the plots in their spare time.

The size of allotment plots varies very much, ranging from four poles to forty poles. A useful size is one of about ten poles (300 square yards). The rent charged for these plots varies from 6d. to 1s. per pole.

The disadvantages of allotment gardens when compared with cottage gardens are—(1) distance from the home of the worker; (2) less privacy; (3) less security for produce grown.

Allotment holders with limited experience should proceed cautiously at first, as it is found that the climate and soil vary very much in different districts. The methods of cultivation, manuring, kinds and varieties of crops to be grown, must be adapted to meet local conditions; intelligent cultivation and suitable manuring will, however, overcome many difficulties in this respect.

VACANT BUILDING PLOTS.

In some of our large towns and cities it may be difficult to obtain land for allotment purposes, but usually there are to be found many vacant plots, ultimately intended for building purposes, which in the meantime could be fenced, sub-divided, cultivated, and utilised for the production of food.

To make such a scheme a success, a few enthusiastic persons should combine and form an Association to make arrangements with the owners of any vacant or waste land, and take over the same until actually required for building on; also to fence, level, and divide the land into plots of a convenient size, and endeavour to get suitable tenants to take up plots. If the Association could obtain subscriptions, or a grant from the Common Fund of the Town Council, for such a laudable purpose, then not only might many vacant pieces of land be turned to good account, but they would be the means of largely increasing our food supplies.

CULTIVATION OF THE SOIL.

Having obtained a plot of land, the first thing to do is to break up the soil. This is usually done in the autumn, winter,

or spring. It would be difficult to over-estimate the beneficial effects of deep cultivation, and laying the soil up to the action of frost.

When fresh ground is broken up, it should be dug two spades deep. This is known as double digging or bastard trenching. Skim off the turf about two inches deep from the first trench, which should be about twenty to twenty-four inches wide. Lay the turf aside, and take out the top spade depth of soil, placing it in a heap beside the turf. Next dig over or break up thoroughly the subsoil, and on this turn upside down the turf layer from the second trench. The top spade depth of the second trench should be turned over on the turf to fill up the first trench. Continue this process until the whole area has been dug two spades deep, keeping the top soil still on the surface. Use the turf and soil from the first trench to level up the last in finishing the work.

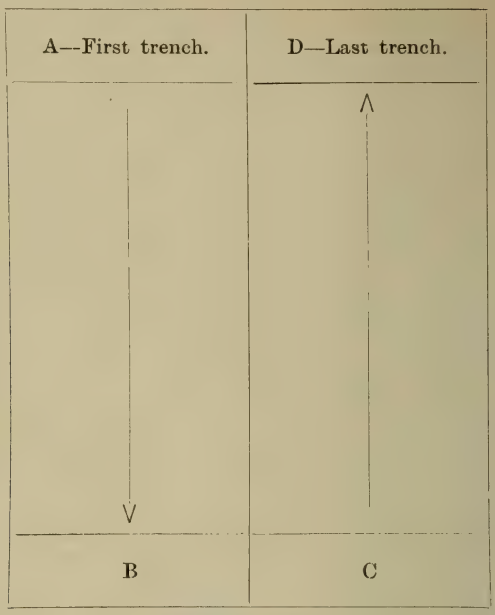
In the case of land that has been lying waste or has become full of noxious weeds, such as couch-grass, horsetail, coltsfoot, bishop-weed, docks, or dandelions, care should be taken to pick out the roots or underground stems of these during the process of digging, for if dug in they will grow again. Other weeds, of an annual nature, such as chickweed, groundsel, &c., may be dug in, as they quickly rot, and thus add to the fertility of the soil.

METHODS OF DIGGING SOIL.

1. *Simple Digging* consists in turning the soil to the depth of a spade, *i.e.*, 9 to 12 inches, or one "spit" (spade) deep, and is performed in the following manner :—

Commence operations at the end of the site to be dug by opening a trench one foot wide and a "spit" deep. If the portion to be dug is narrow, the soil from the first opening will have to be wheeled to the opposite end of the site, and deposited there in readiness for filling in the last trench. Should, however, the land be sufficiently wide, it will be found convenient to divide it into two portions, as shown in the sketch. In this case the soil from the first trench A should be

placed alongside the last trench D, and when B is dug the soil from C will be utilised for filling B.



Simple Digging.

2. *Double Digging or Bastard Trenching.*—In this case the soil is worked two "spits"—about 18 inches—deep, the subsoil being retained in its original position.

Open a trench A a "spit" deep, and two spades (about 18 inches) wide, shovel out the "crumbs"—the loose soil—and wheel the whole to a position convenient for filling in the final trench. The subsoil B should then be forked over, and the soil from C turned over on top of it, levelling off with the "crumbs" prior to forking the subsoil D.

A	C	Surface soil.
B	D	Subsoil.

Double Digging.

Raking is a means of loosening the soil, disturbing weeds, and breaking up lumps or clods, and is useful for levelling and for obtaining a fine surface. Raking is by no means so simple as it looks, requiring considerable practice and dexterity of action. It is not necessary or desirable to remove all the stones from the surface, but only the largest.

Hoeing or surface cultivation is of great advantage to growing crops. Weeds are killed and checked. The ground is kept more moist, air admitted, and a fine surface tilth formed which prevents cracking and loss of moisture. Crops make greater progress, mature earlier, and generally command a better price, which more than compensates for the extra cost of labour incurred.

Weeding.—This operation in the case of young weeds is best done by means of the Dutch hoe, or if the weeds are very large or occurring among seedlings, they should be removed by hand. Deep-rooting kinds, or those with underground stems like couch grass, coltsfoot, horsetail, bishop-weed, bind-weed, &c., should be removed by means of a fork or spade, and afterwards burned.

Earthing up plants with soil encourages a greater development of stem or leafstalk, and by blanching them, causes the plants to be more tender and succulent; examples—celery, leeks, and seakale. Peas, beans, cauliflowers, and cabbages are sometimes earthed up to keep the plants firm in the ground and encourage the production of lateral roots. Potatoes are earthed up (1st) to prevent frost from damaging the tender shoots, (2) to encourage more underground stems to arise from the haulms and thus add to the yield of the crop, and (3) to prevent the tubers greening by exposure to light.

Thinning or singling plants such as turnips, carrots, onions, parsnips, beet, or spinach, results in larger and more uniform produce. Early thinning prevents the attacks of insect pests and damage to the roots, and all thinning is best done in showery weather.

Transplanting is practised with leeks, onions, cabbage, greens, cauliflower, lettuce, &c., but not with tap-rooted crops,

such as carrots, parsnips, beetroots, and turnips. It is best done when the soil is moist, or in showery weather. Should hot dry weather immediately follow, give the soil a good soaking of water at intervals until the plants are established. The soil should be made firm about the roots after planting.

MANURING GARDEN CROPS.

Manures may be classified as (*a*) artificial and (*b*) natural.

Artificial manures are those which have come into use since about 1840. They are obtained from the manufacturer or merchant.

Natural manures have been in use from time immemorial; being home or farm products, they do not generally pass through the manufacturer's hands.

(*a*) Artificial manures, such as nitrate of soda, sulphate of ammonia, lime nitrate, and nitrolim, should be used very sparingly as top dressings for growing crops, at the rate of ½ oz. to 1 oz. per square yard; showery weather being the best time to apply. Care should be taken to prevent the manures coming in contact with foliage more than is possible.

Superphosphate is fairly quick acting, and may be used at the rate of 2 to 3 oz. per square yard, as a top dressing for growing crops; or it may be forked into the soil or placed in the drills before planting or sowing.

Bone meal and bone flour are also good sources of phosphate, and may be used at the rate of 3 to 4 oz. per square yard as top dressing, or worked in the surface soil before planting.

Basic slag should be used quite freely for most garden soils, and for most crops, at the rate of 4 to 8 oz. per square yard.

Kainit may be applied in winter at the rate of 4 oz. per square yard, being forked in the surface soil after the digging has been done.

Sulphate of potash may be used at the rate of 1 oz. per square yard, at the time of planting, or as a top dressing during the growth of the crop.

Wood ashes contain 5 to 10 per cent. of potash, and are very valuable for digging in the soil, or as a top dressing for many crops.

Lime and salt, to a certain extent, will liberate potash already existing in the soil. Seaweed or wrack, in districts near the sea, should be used very largely as manure, as it supplies much potash.

Lime exists in soil as carbonate of lime. It is extremely valuable for clay soil, sour soil, peat soil, and heavily manured land. An application of lime will benefit nearly all crops. The old practice was to apply lime every 6 or 10 years, but more frequent applications are now the rule. Ten to twenty cwt. per acre every three years is considered a light dressing, and one to two tons or more during the same period constitutes a good dressing. For garden purposes, a half to one bushel per pole, or a half to 1 lb. per square yard, is the quantity usually applied.

Soot is a very valuable manure, and may be dug into the soil ($\frac{1}{2}$ bushel per pole) or used as a top-dressing for many crops, such as onions, carrots, beet, greens, &c. Sprinkled over seedlings, it acts as an insecticide, keeping away various pests (snails, caterpillars, &c.). Soot is sometimes of very poor quality indeed; that of a light velvety or fluffy nature being best. Soot fresh from flues should not be used.

(*b*) Natural manures are complete manures, supplying nitrogen, potash, and phosphates, and may be applied with good results. Containing as they do, a large quantity of organic matter, their use has a beneficial effect on all classes of soil. The principal kinds are farmyard manure, stable manure, poultry manure, pig manure, seaweed, &c. These manures may be applied at the time of digging or at the time of planting, at the rate of 3 to 4 barrow-loads per pole.

How to Apply Manures.—Natural manures are dug into the soil, whilst basic slag, kainit, lime, bone meal, and superphosphate, may be applied to the surface and forked in.

Sulphate of ammonia, sulphate of potash, nitrate of soda, Peruvian guano, superphosphate, &c., may be used as top-dressings, and should be accurately weighed and spread evenly to ensure good results.

HOW TO OBTAIN MANURES, IMPLEMENTS, &c.

Cultivators should take care of all waste products, such as animal manures, leaf-mould, and soot, for application to the soil.

Cottage garden or allotment associations and horticultural societies would be doing a great service to their members if they would purchase some of the principal kinds in bulk in the original bags, and retail in small quantities, among those requiring them, at a little over cost price. This co-operation among plot-holders and cottagers might be extended, thus enabling them to obtain lime, plant washes, fencing material, seeds, potatoes, and garden implements. A knapsack spraying machine for spraying potatoes, &c., costing from 40s. to 50s., could be purchased by the society, and let out at a nominal cost to members.

SEED SOWING.

Seeds may be sown broadcast by hand over the surface of the soil, which should then be raked or harrowed to cover the seeds. In garden practice, however, seeds are generally sown thinly in drills, drawn by a hoe or rake, at depths varying from $\frac{1}{4}$ inch to 3 or 4 inches, according to the size and kind of seed and also the character of the soil.

Soil for the reception of seed should be even and firm, with a fine loose surface, not pasty or sticky, nor dust dry. After sowing, particularly on light land, press the surface down with the back of the spade, to conserve the soil moisture.

It is necessary to sow at the proper depths, placing small seeds near the surface, and larger seeds proportionately deeper; and in all cases to sow somewhat deeper than the average in a light sandy soil, and nearer the surface in a heavy clay.

Thin sowing should be the regular practice, and afterwards early thinning out, not only from an economical point of view, but in order to get strong, sturdy plants. The aim should be to obtain a strong, vigorous germination in the first instance, and later to avoid overcrowding, as that is ruinous to young plants.

Appended is a Seed Table showing the depths at which to sow in a medium soil, and the approximate quantities of seed required :—

SEED TABLE.

Kind of Seed.	Quantity-Length in Drills.	Depth to Sow.	Distance apart—	
			Rows.	In the Rows.
Broad Beans, -	1 pint to 50 feet,	3-4 ins.,	30 ins.,	6-8 ins.
French Beans, -	1 „ 170 „	2-3 „	24 „	6 „
Runner Beans, -	1 „ 35 „	3-4 „	6 feet,	6-8 „
Early Peas, -	1 „ 65 „	2 „	2-3 „	—
Main Crop Peas,	1 „ 80 „	2-4 „	4-6 „	—
Turnips, - -	1 oz. to 200 „	1 in.,	12 ins.,	6-8 ins.
Carrots, - -	1 „ 250 „	1 „	12 „	6-8 „
Parsnips, - -	1 „ 180 „	1 „	15 „	9 „
Beet, - -	1 „ 50 „	1¼ „	15 „	9 „
Onions, - -	1 „ 170 „	1 „	12-24 „	6-9 „
Leeks, - -	1 „ 150 „	1 „	12-24 „	6-12 „
Celery, - -	½ „ 6 sq. yds.,	¼ „	4 feet,	9 „
Parsley, - -	1 „ 200 feet,	¼ „	12 ins.,	6-8 „
Radish, - -	1 „ 60 „	1½ „	12 „	—
Lettuce, - -	¼ „ 140 „	¼ „	12 „	9-12 ins.
Cabbage Family,	1 „ 150 „	¾ „	24 „	18-24 „
Potatoes, - -	1 stone to 112 „	4 „	24-30 „	12-18 „

Birds are very fond of seedlings, and give a lot of trouble, especially in hot weather, the tender and sweet young sprouts being very palatable to them. Freshly mown short grass may be scattered over the surface of seed beds, or black thread fixed over the rows will be found a useful protection from birds. The thread may be fixed to pegs 6 to 9 inches in length, these being pushed about 3 inches into the ground and the thread stretched tightly from end to end, about 3 inches above the soil.

Mice, too, sometimes give trouble, especially in the case of large seeds like peas, beans, and the seeds of trees. As a protective measure, damp the seeds and shake them up in red lead, or soak them in paraffin oil for an hour before sowing.

Seedlings of vegetables and flowers are often attacked by slugs. The damage, however, may be greatly reduced by applications of soot, or fine slaked lime in the form of powder, over the plants at frequent intervals. In the case of seed sown in pots or boxes, it is desirable that the soil be sterilised by pouring boiling water over it. This kills all insects and insect eggs, otherwise tiny slugs and snails are apt to hatch and destroy the seedlings.

CROPPING PLAN.

There are many ways of cropping a garden plot according to its size, shape, and the requirements of the cultivator.

Some persons confine their attention to a single crop, such as the potato, cabbage, greens or leeks, whilst others cultivate a larger variety of useful crops.

The following Plan is given in the hope of being useful to beginners. It represents a plot of 150 square yards or 5 poles. The cropping of larger or smaller plots can be adapted accordingly by increasing or diminishing the number of kinds grown or the area devoted to each.

It is advisable to arrange that the rows run north and south if possible, and that the position of the various crops be changed each year.

The quantities and cost of seeds or plants required and also the yield and value of the crops grown can only be approximate (war-time prices) as prices vary very much. The figures are given, however, to afford some indication of what is possible under favourable conditions as regards weather, soil, situation, and care bestowed upon the plants such as thinning, hoeing, weeding, manuring, &c.

Succession crops such as leeks, cabbage, sprouts, savoy, and kale may be planted after potatoes or peas are harvested.

30 ft.

6 in.	**Radishes**
12 in.	**Peas**
18 in.	**Shallots, Lettuce, Mustard or Cress**
18 in.	**Early Potatoes,** 15 inches apart = 24
24 in.	,, ,, ,, ,, ,,
24 in.	,, ,, ,, ,, ,,
24 in.	,, ,, ,, ,, ,,
24 in.	,, ,, ,, ,, ,,
30 in.	**Maincrop Potatoes,** 15 inches apart = 24
30 in.	,, ,, ,, ,, ,,
30 in.	,, ,, ,, ,, ,,

CROP

LENGTH OF PLOT, 45 FEET. BREADTH, 3

The lines indicate the centre of each row. The distances

30 in. **Broad Beans,** double row, seed 6 inches apart

24 in. **Turnip,** Snowball or other early, thin to 6 inches apart

12 in. ,, Golden Ball, thin to 9 inches apart

18 in. **Swede Turnip,** thin to 12 inches apart

12 in. **Carrot,** thin to 4 inches apart

12 in. **Beet,** thin to 6 inches apart

18 in. **Parsnips,** thin to 9 inches apart

12 in. **Leeks,** plants 6 inches apart

12 in. ,, ,, ,, ,,

18 in. **Cauliflower,** plants 18 inches apart

18 in. **Cabbage,** plants 18 inches apart

24 in. **Onions, Shallots, Salad or Seed Bed**

24 in. **Parsley Edging,** thin to 6 inches apart...
6 in. Edge of Plot

30 ft.

PLAN.

, 150 SQUARE YARDS = 5 POLES = $\frac{1}{32}$ ACRE.

1 case from the centre of one row to the centre of the next.

Crop.	Length of Row.	Number of Plants.	Quantity and Cost of Seeds, &c.			Estimated Value of Produce.		
				s.	*d.*	£	*s.*	*d.*
Radishes	30 ft.	160 plants	2 oz.	0	6	0	2	0
Peas	30 „	300 „	½ pint	0	9	0	3	6
Lettuce or Mustard, &c.,	30 „	—	say	0	8	0	3	0
Early Potatoes	150 „	120 plants	14 lbs.	4	0	12 Stone. 0	18	0
Maincrop „	150 „	100 „	14 lbs.	3	6	18 Stone. 1	2	6
Broad Beans	30 „	60 to 90 „	1 pint	1	0	0	3	0
Turnip, Early	30 „	60 – 80 „	½ oz.	0	3	0	2	6
„ Golden Ball	30 „	50 – 60 „	½ oz.	0	3	0	2	6
Swede Turnip	30 „	30 – 40 „	½ oz.	0	2	0	2	6
Carrots	30 „	80 – 100 „	½ oz.	0	5	0	3	0
Beet	30 „	50 – 60 „	½ oz.	0	6	0	4	0
Parsnips	30 „	40 – 50 „	½ oz.	0	4	0	3	0
Leeks	60 „	120 „	½ oz.	0	8	0	4	0
Cauliflower	30 „	20 „	plants	1	0	0	4	0
Cabbage	30 „	20 „	„	0	6	0	3	0
Onions or Shallots	60 „	120 „	say	1	0	0	5	0
Parsley	30 „	60 „	¼ oz.	0	2	0	4	0
Extras— Kale, Sprouts, Savoy, Cabbage, Cauliflower	To follow Potatoes, Peas, &c. 300 ft.	about 200 „	say	3	6	0	11	6
Onion Sets	—	100 „	½ lb.	0	10	0	3	6
Leeks	—	250 „	plants	1	6	0	8	0
1 ton of Manure	—	—	say	10	0		—	
3 bushels Lime	—	—	„	5	0		—	
Rent	—	—	„	3	6		—	
Tools	—	—	„	10	0		—	
Extra Seeds	—	—	„	1	0		—	
				£2	11	0	5	12	6
							2	11	0
		Profit					3	1	6

It will be seen from the above that the cost of a 5-pole plot works out at £2 11s., and the value of the produce at £5 12s. 6d., thus giving a profit of £3 1s. 6d., or about 9d. per square yard = £1 2s. 6d. per pole or £180 per acre.

THE CULTURE OF VEGETABLES.

The Potato succeeds best in a good friable loam, well drained, and well worked. Clay soil should be trenched or double dug in autumn or winter, and road scrapings, sand, leaf mould, or burnt garden refuse worked in. Light land should have plenty of well-rotted manure applied.

The soil should be well forked over in March to sweeten it, and the potatoes planted about the end of April when the soil is fairly dry. The sets may be planted 4 inches deep, and 12 to 18 inches apart, the rows being 2 feet to 2½ feet from one another. Sprouted sets are more satisfactory than unsprouted sets. Sprouting may take place in shallow boxes kept in a light, dry, but frost-proof shed. A change of seed is very desirable every two or three years. When the shaws (stems) are 6 inches high, the soil may be loosened by means of a fork, and the plants earthed up.

Early varieties:—

Epicure, May Queen, Midlothian Early, Ninety-fold.

Second Earlies:—

Abundance, British Queen, Conquest, Great Scot, Windsor Castle.

Late varieties:—

Arran Chief, Dalhousie, Golden Wonder.

Green Peas require plenty of space and soil in a high state of cultivation. The seed may be sown, 3 to 4 inches deep, from January to July, for a succession of crops over a long period, or from March to June in cold localities. Where mice or birds are troublesome, the rows may be covered with fine cinders and frequently sprayed with paraffin emulsion or some other strong-smelling insecticide. Or pea guards may be used to keep away birds. Earthing up of the young plants must be attended to as soon as they attain a height of 4 to 6 inches.

Early staking is necessary in the case of tall growers. During dry weather the plants may be mulched with short manure or lawn clippings, and watered freely.

Broad Beans are very hardy; seeds may be sown from February to March or April, 4 inches deep and 6 inches apart. It is advisable to pinch the tops of the plants as soon as the pods are forming.

Turnips do best in good, rich, cool, moist soil, with a supply of phosphates such as bone meal, basic slag, or superphosphate.

Seeds may be sown from April to June for a succession of tender roots. Very early sowing will cause the plants to "bolt," especially in the north. Sow thinly in drills 1 inch deep and 1 to 1½ feet apart, and thin out when large enough to handle.

In the north swede turnips are greatly in request during the winter. These are hardy, and keep well for a long period.

Cabbage for spring and early summer use may be sown on a nicely prepared seed bed about the middle of July.

Cabbage for summer, autumn, and winter use are obtained by one or two successive seed sowings, in April or May, on a sheltered and well-prepared seed bed, and the seedlings transplanted in May, June, or July, when the weather is suitable.

Savoy cabbage, broccoli, Brussels sprouts, curly kale (borecole), asparagus kale, cottager's kale, sprouting broccoli, and coleworts may all be sown in April and planted out when the weather is favourable, or when the land is ready for their reception. They require good, firm, not over rich soil, and may be planted 18 inches to 2 feet apart, with 2 to 2½ feet between the rows, according to kinds.

Cauliflowers are gross feeding plants, and therefore require deeply worked soil with plenty of manure. The addition of one bushel of lime per pole, before planting, will be beneficial to the plants. When grown on poor ground growth is slow, and the plants are liable to "button," *i.e.*, to form small heads prematurely. This may also occur if the plants have received a check in the young state.

Seeds are sometimes sown in the autumn, wintered in frames, and planted out in April for early crops. Or seed may be sown in heat from February to March, or outdoors on a warm sheltered border in April, for providing "heads" for summer and autumn use.

Young plants of cauliflower, cabbage, kale, and sprouts are available from shops in spring for planting.

Onions.—Every allotment holder and cottager delights in growing large onions. Their successful cultivation, however, depends upon a variety of circumstances, such as well manured, deeply worked soil, and facilities being available for bringing on the seedlings in readiness for planting out in April. Firm soil is essential to good growth. Seeds are sown in pots or boxes, under glass, from January to March, the seedlings pricked out into boxes of rich soil, kept near the glass, and eventually gradually hardened off preparatory to being planted out. Seeds may also be sown outdoors from March to April, but it is only in warm districts that outdoor sown onions grow to a large size. A good useful crop may be obtained by outdoor sowing if the ground is treated liberally, and plenty of soot, powdered lime, or some soil fumigant such as "Killogrub" or "Vaporite" worked into the soil before sowing, and frequent dustings of soot given when the seedlings appear. The seedlings should be thinned to about 6 to 9 inches apart, and the thinnings may be utilised for transplanting or for salad purposes.

Young onion plants from hothouses or frames may be planted 9 to 12 inches apart, 14 inches being allowed between the rows. A trowel will be found useful for this operation, and care should be taken to spread out the roots, to keep the upper half of the young bulb above the surface of the soil, and to press the soil firmly round each. Transplanted onions are less liable to the attack of the onion fly maggot than those raised in the open.

Constant attention to the seedlings by frequent dustings of lime or soot, or spraying with some insecticide, will do much to prevent egg-laying by the onion fly. The use of bone meal, superphosphate, or potash, will assist the plants (see page 174).

The bulbs are lifted, dried, and stored in a dry, frost-proof place until required for use.

Onion sets, *i.e.*, small onion bulbs of the previous year's growth, in a dry dormant condition, are now obtainable from seedsmen from 1s. to 1s. 6d. per pound. One pound will

contain about 200 of these small bulbs. They may be planted in March, 6 to 8 inches apart, on well-prepared ground, in the same way as shallots. Very good crops are produced in this manner, and usually free from the onion fly maggot. The bulbs do not keep long.

The Shallot is a perennial, and its bulbs are planted in March, 6 to 9 inches apart, being lifted when the leaves turn yellow.

Carrots do best on light sandy soil, especially when newly broken. Seed should be sown thinly in drills, 1 inch deep, from April to May, and again in June. The late sowing generally escapes an attack of the carrot fly maggot, and provides nice tender roots for autumn and winter use. Showery weather is the most suitable time for thinning the seedlings, and care should be taken to keep the shoulders well covered with soil. The use of soot, &c., as recommended for onions, will do much to minimise attacks of the carrot fly.

Carrots may be stored in sand or ashes, in a cold cellar or shed. In some favourable districts, however, they may be left in the ground practically all the winter—especially those sown late—and lifted as required.

Parsnips, as regards soil and general culture, may receive much the same treatment as carrots.

Seed may be sown in February, March, or April, 1 inch deep, in rows 15 inches apart, and the seedlings thinned to 9 inches apart.

Parsnips, on account of their hardiness, may be left in the soil all the winter, and lifted as required for use.

Beetroot is a tender plant, and should not be sown quite so early as the carrot; April or May will be early enough. The general culture is the same as for carrots. A slight dressing of common salt or rotted seaweed is beneficial. The round turnip-rooted kinds are early, and do well on soils that are not adapted to deep-rooted varieties.

The roots must be lifted carefully in the autumn, to prevent them being damaged, as this would cause a loss of colour through "bleeding." They may be stored in a frost-proof

shed or cellar, being placed in layers and covered with sand to keep them fresh.

When difficulty exists in growing good carrots, parsnips, or beetroot, holes may be bored in the ground 2 to 3 feet deep, and 3 to 4 inches in diameter, and filled with a prepared compost. This compost should consist of two parts sifted sandy loam or old potting soil, two parts sifted leaf mould, and one part burnt vegetable refuse or wood ashes, with the addition of 1 lb. of bone meal to every bushel of the compost. Three or four seeds are then placed in each filled-up hole and finally thinned, leaving one plant in each.

Leeks are very hardy, and form a most useful garden vegetable. Large leeks are obtained by sowing the seed under glass, as recommended for onions, planting outdoors in well-manured trenches, and gradually earthing up to cause blanching, and larger growths. Paper collars for blanching purposes are used by some growers.

Good useful crops may be had by sowing the seed outdoors in April, transplanting in June or July, 6 to 9 inches apart in trenches on well-manured ground, and earthing up as required.

Lettuce.—Both cos and cabbage varieties are generally sown on seed beds and transplanted to any vacant ground, 9 to 12 inches apart. Early supplies are obtained by sowing under glass in February or March, gradually hardening off, and planting out on a sheltered border. Three or four sowings may be necessary to keep up a supply.

Lettuce require fairly rich, cool, moist soil to encourage quick growth, giving succulent and tender plants.

Radishes, of which there are several kinds—long, short, red, pink, white, olive, and black—require to be sown on rich, cool, moist soil, to encourage rapid growth, which results in tender, juicy roots. Radishes, like other salad plants, require to be grown quickly, or they may be tough and bitter. They should be used in a fresh, young state.

Mustard and Cress are two popular annuals easily grown. A little warmth and shade encourages quick growth. They are cut when about 2 inches high, and frequent sowings will

be necessary to keep a supply. Winter and spring crops must be sown under glass.

Parsley is one of the principal herbs grown in Scottish gardens. Seeds may be sown from March to end of April, in drills ½ inch deep and about 12 inches wide; the young plants are thinned so as to stand 6 inches apart.

The soil should be well worked and manured, and given a dressing of soot, wood ashes, bone meal, basic slag, or lime to encourage healthy growth.

A second sowing of seed is sometimes made in June to maintain a supply during winter and spring. In some districts frame protection will be necessary to ensure a supply of parsley during winter.

STORAGE OF ROOT CROPS FOR WINTER USE.

It is important to preserve from frost such root crops as carrots, beetroot, and turnips. These may be lifted in October or November, before the advent of hard frost, trimmed, and stored with alternate layers of sand or dry soil in a cool frost-proof cellar or shed. In some districts turnips and swedes may be left in the ground and lifted as required for use. The latter method is the best to adopt for Jerusalem artichokes and parsnips, which are quite hardy and are improved by being left in the ground.

Onions, after being lifted and allowed to dry on the ground for a few days, should be "bunched" and hung up in a shed or any place where they will be kept dry. Light or frost does not harm them, but moist conditions must be avoided.

Potatoes should be stored either in cellars or light-proof and frost-proof sheds. Where small quantities are concerned this is preferable to the making of "pits" or "clamps."

Potato tubers for planting may be selected at the time of lifting the crop, choosing medium-sized tubers. These should be exposed to light and air, to harden and green them, and to produce short, sturdy sprouts, but the tubers must be protected from frost. It is desirable to sprout carefully a few good early kinds and plant them on sheltered borders or in frames for early use.

INSECT AND OTHER PESTS OF VEGETABLE CROPS.

Preliminary Observations.—Nearly all plants, when grown in large quantities, and under conditions of a more or less artificial nature, are liable to be attacked by some kind of pest—animal or vegetable. Generally, however, these pests can be prevented, or held in check, by one or other of the many methods now known to cultivators.

Soot may be applied with advantage in the case of leaf and root pests. It should be dusted over the plants at frequent intervals, being most efficacious when the foliage is damp.

Salt, applied at the rate of 4 oz. per square yard, or 10 to 12 cwt. per acre, or gas lime, 1 lb. per square yard, are both useful for such soil pests as wireworm, leather jacket, chafer grubs, &c. They should be applied when the land is free from a crop.

Wood Ashes is beneficial in some cases for soil pests, being, in addition, of some manurial value to crops.

Lime, when used freshly slaked, destroys certain soil pests, and can also be used as a preventive against attacks of the celery, onion, carrot, and beet flies.

Cabbage-root maggot or cabbage fly.—The maggots attack the roots and stems of the cabbage, cauliflower, and turnip.

Preventives and remedies:—(1) Less animal manure and more artificial manures such as kainit, superphosphate, and nitrate of soda should be used.

(2) Lime may be applied.

(3) Destroy all badly infested plants.

(4) Practice rotation of cropping and trench deeply to bury the larvæ.

(5) Before transplanting, the roots of the plants may be dipped in a mixture of clay, soot, paraffin, and water.

(6) A teaspoonful of nitrate of soda placed round the collar of the plants after transplanting has proved efficacious in some cases.

(7) Soot or gas lime spread round the plants has also proved effective.

Cabbage moth and white cabbage butterfly.—The caterpillars feed on the leaves of cabbages and allied plants, and may be destroyed by (*a*) hand-picking; (*b*) dusting the plants with lime, soot, or gas lime powder; or (*c*) spraying with brine or lime water. General cleanliness in the garden, rotation of crops, and deep cultivation will all have a tendency to hold these pests in check.

Onion fly.—The maggots are hatched from eggs deposited by the fly at the bases of the leaves of the seedlings.

Plants raised under glass and transplanted are less liable to be attacked than those sown in the open. The planting of small onion sets (small dry bulbs, about the size of marbles), gives good results in many gardens, and should be tried in districts where onion cultivation is generally a failure. Many are the remedies suggested for this troublesome pest, and the following are among the most suitable :—

(1) The onion bed should receive a good dressing of lime, soot, wood ashes, or gas lime, and be deeply dug in order to bury the chrysalis.

(2) Before sowing the seed treat the seed drills with spirits of tar, 1 gallon to 2 bushels of peat or sand. This is sufficient for a row 60 yards long.

Paraffin or sheep dip mixed with sand or peat may be used in a similar manner.

(3) The seedlings, or newly transplanted plants, should be dusted at frequent intervals with soot or lime; or "Vaporite," "Vossolite," &c., might also be useful for this pest.

(4) All infested plants should be carefully lifted by means of a handfork, keeping the soil attached, and the whole burnt.

Carrot fly.—The foregoing remarks concerning the onion fly are applicable here, with the exception that carrots are not usually transplanted.

Avoid thinning the plants in very dry weather, and give a good watering immediately the operation is completed.

Drawing soil over the crowns of the seedlings is an additional preventive measure. Grass clippings from the lawn sprinkled lightly over the seedlings of carrots, turnips, &c., also help to keep away troublesome pests.

Turnip flea beetle.—This insect—the so-called "Turnip Fly"—causes immense damage to the turnip crop (and other closely related plants) in the early stages of its growth, by feeding on the young fleshy seed leaves (cotyledons). The presence of these small beetles is especially noticeable during hot, dry, or very cold dry weather, when growth is slow. It is therefore important to sow on a well-prepared seed bed, during weather suitable for rapid growth. Superphosphate, or some other artificial manure, drilled in with the seed—which should be new—will encourage quick growth.

Soot, lime, or dry road sweepings dusted over the plants will tend to keep the pest in check.

All cruciferous weeds should be destroyed.

Wireworm.—The wireworm is the larval stage of the click beetle, or skip jack. Unlike most insects, it remains in the grub stage for three or four years, causing much damage to all kinds of crops during this period of its existence.

There is no royal road to success in dealing with this pest, but many of the following remedies may prove effectual:—

(1) Good clean cultivation of the soil, to destroy suitable places for egg-laying.

(2) Constant working of the soil will kill many of the pests as they change from one stage to another.

(3) Good drainage is desirable.

(4) Liming the soil, together with the use of nitrate of soda or kainit, will stimulate growth, thus giving the crops a good start, and at the same time cause some harm to the pests.

(5) Soot worked into the soil is attended with beneficial results.

(6) Hand-picking can be resorted to in the case of soil used in greenhouses, or when digging the soil in the garden.

(7) Traps, consisting of pieces of carrot, potato, apple, rape cake, &c., may be inserted in the soil, examined at intervals, and all grubs destroyed.

(8) The grubs show a great liking for rape dust and mustard plants, and the former placed between the crops, and the latter sown as an inter-crop, will attract wireworms, leather jackets, and chafer-grubs from the main crop under cultivation.

Leather jacket.—The leather jacket is the larva of the crane fly or daddy longlegs.

The larvæ do immense damage to the roots of crops. especially on newly-broken land. The eggs may be introduced into gardens by means of half-decayed leaves, road sweepings, manure, &c., from a badly-formed compost heap.

Hand-picking the grubs has proved effective in many cases, a pointed stick being used to remove the soil from around attacked plants. The remedies suggested under "Wireworms" are also applicable to this pest.

Chafer-grubs.—One of the commonest is the larva of the May bug (*Melolontha vulgaris*). The beetles are light brown in colour, and are very plentiful on summer evenings, especially in some seasons and districts, when they occur in great numbers.

Hand-picking, good, deep, and constant cultivation, and the use of stimulating manures to encourage quick growth, will do much to keep down this pest. Plants not thriving should be carefully examined at the roots to ascertain whether or not the cause is due to the presence of these larvæ.

Slugs and snails.—Both slugs and snails are very troublesome in damp or shady gardens, doing a considerable amount of damage to choice plants.

The following are among the many remedies which may be tried :—

(1) Cleanliness in the garden, destroying all rubbish, &c., which might afford shelter.

(2) Deep autumn cultivation of the soil.

(3) Hand-picking at night, especially after rain.

(4) Trapping by means of cabbage or rhubarb leaves, or with boards laid near their haunts. These should be examined daily, in order that the pests may be destroyed.

(5) Sharp sand, soot, salt, wood ashes, charcoal dust, or granite chips placed round the plants, or lime put down two or three nights in succession, has proved effectual. One dusting of lime is not sufficient to kill slugs, but two or three applications will destroy them before they have had time to renew their coats.

(6) Strong lime or salt water may be effective under certain conditions.

Club root, or Finger-and-toe.—This fungus, which attacks turnips, cabbages, &c., is capable of existing in the soil for several years without the presence of a host plant. Practically all members of the cabbage family (*Cruciferæ*) may be attacked by this disease if grown on infected soil. Turnip, cabbage, kale, cauliflower, radish, mustard, cress, wallflower, honesty, candytuft, &c., and such weeds as shepherd's purse, charlock, and wild radish (runch) are all attacked, hence the importance of keeping infected land clear of such crops and weeds whilst attempting to destroy the fungus by liming (gas lime or burnt lime), or some other method of soil sterilisation.

Remedies and Preventives.—(*a*) Quicklime applied in autumn at the rate of 28 lb. to 56 lb. per pole, after the crop affected has been removed.

(*b*) A complete change of crop when planting the infected piece of land again.

(*c*) Avoid the use of manures such as superphosphate and sulphate of ammonia.

(*d*) Basic slag and potash give good results.

(*e*) When planting, dip the roots of cabbage or cauliflower plants in a puddle made by mixing clay or soil with soot and sulphur.

Potato wart disease, or black scab.—No cure has yet been discovered for this disease, which seems to be spreading.

It is noteworthy that this disease is most prevalent in cottage and allotment gardens, due, probably, to continuous cropping of potatoes on the same piece of land, neglecting to destroy any diseased tubers, and receiving "seed" in exchange which may have been grown on infected land.

Preventive measures which may be adopted.—(*a*) Good clean cultivation.

(*b*) Burn diseased crop, or boil before feeding to pigs.

(*c*) Liming the soil.

(*d*) Change the potato crop for some other as recommended under "Club root."

(*e*) Grow those varieties of potatoes least liable to attack, *e.g.*, Aberlady Early, Abundance, Conquest, Crofter, Golden Wonder, Langworthy, Peacemaker, Provost, Discovery, Great Scot, &c.

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A REPORT

ON THE

RESULTS OF EXPERIMENTS ON

BRACKEN

UTILISATION AND ERADICATION,

BY

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Professor of Agricultural Chemistry.

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BRACKEN

UTILISATION AND ERADICATION,

BY

Professor R. A. BERRY.

In Bulletin No. 73, on the Composition of Wood and Plant Ashes, it was shown that the ash of bracken was particularly rich in potash. This point was the subject of further investigation in the summer of 1916, and the present report deals with the results obtained.

Articles on the eradication of bracken and on the economic uses to which the dry bracken might be put have appeared of late years in the Journals of the Highland and Agricultural Society of Scotland and of the Board of Agriculture and Fisheries, also in the daily press and in other publications. The reason being that the encroachment of bracken upon upland pastures, hill grazings, and on land suitable for afforestation and other purposes. has made considerable headway in certain parts of the country, the land invaded being greatly reduced in value. The plant, when once established, spreads by means of underground rhizomes, which makes it a pest particularly difficult to overcome. Moreover, it is very cosmopolitan in its choice of ground, as it grows on most types of soil and in almost any situation up to an elevation of fifteen hundred feet or more; stony soils in sheltered positions and of a moist and acid nature are preferred.

AS A SOURCE OF POTASH.

Reference to earlier literature shows that in some of the mountainous districts in Wales where bracken grows abundantly the plant was cut down in the summer, and, after drying, it was burned in large heaps by the cottagers, for the sake of the alkali contained in the ash. When sufficiently burned, enough water was sprinkled over the ashes to make them adhere together. They were then rolled into round balls about two inches in diameter, dried, and sold as ash balls. They served the purpose of economising the use of soap. Before use, the balls were placed in a fire, and when thoroughly heated were put into water, which thus became a strong lye. The ashes were also employed for the manufacture of soap and glass.

Samples of bracken ash analysed in the autumn of 1914 (see Bulletin already referred to) contained about 25 per cent. of potash, but some containing as low as 2 per cent. and some as high as 30 per cent. have also been recorded. The reason for this seemingly great variation was the primary object of the inquiry carried out last summer. Such factors as stage of growth, soil conditions, season, and water-supply, are known to produce characteristic effects on the composition of plants. The influence of stage of growth was investigated on samples taken from three bracken areas in Ayrshire, namely, Dundonald Glen, with a deep fertile soil; Shewalton Moss, with a depth of from six to seven feet of peat; and Cleavance, with a shallow soil in an exposed position on the side of a hill. Samples from each place were cut monthly from May to October, inclusive, one hundred fronds being found to provide a representative sample. The samples were dried, and afterwards burned in a muffle furnace for the ash. The percentage of ash in the dry bracken and of potash in each of the monthly samples is given in the following table :—

Monthly Samplings, 1916.	Percentage Ash in Dry Matter.			Percentage Potash (K_2O) in Ash.		
	Dundonald Glen.	Shewalton Moss.	Cleavance.	Dundonald Glen.	Shewalton Moss.	Cleavance.
May, -	9·4	9·1	—	56	54	—
June, -	7·2	6·1	9·3	53	45	55
July, -	6·4	5·0	6·1	47	42	48
August, -	6·3	5·1	6·3	42	30	45
September,	6·1	4·7	6·4	37	22	40
October, -	3·5	3·0	4·7	21	10	10

The growth at Cleavance was later than at the other two centres. The main features of the table are the extraordinary high potash content of the ash of the young fronds and the close similarity of the three sets of figures, considering the centres represented more or less extreme contrasts in soil conditions. The concentration of potash salts in the ash diminishes as the fronds mature, the rate of diminution being more rapid when the supply of potash in the soil is less, such as in the peat of Shewalton Moss. With the exception of samples taken at the last cutting, over 90 per cent. of the total potash is soluble in water, and the amount remains much the same during the whole growing period. In the samples referred to, the proportion of water-soluble potash fell to between 30 and 40 per cent., and the total potash to between 10 and 20 per cent. The fall was due partly to some migration of potash into the rhizome, but mainly to the fact that the fronds, when cut, were dead, and had been exposed to the leaching action of rain. On treating a coarsely-ground sample of the dry bracken with repeated washings of water, 95 per cent. of the total potash was extracted. Samples of

dead bracken cut during the winter and early spring months have been shown to contain a potash content as low as between 2 and 3 per cent.

To determine the effect of varying soil conditions, additional centres in the West of Scotland were selected, one sample from each being taken in the autumn, when growth had ceased. Several of the samples were quite withered and dead. The following are the figures :—

Centres.	Length of Fronds. Minimum and Maximum Inches.		Ash in Dry Matter. Percentages.	Potash in Ash. Percentages.
Dundonald Glen, -	39″	73″	6·1	37
Shewalton Moss, -	40″	64″	4·7	22
Cleavance, - -	25″	32″	6·4	40
Finnarts-Glenapp, -	27″	45″	9·3	23
,, ,,	54″	75″	5·1	34
Fairgirth, - -	28″	54″	6·7	27
North Cumberhead,	24″	40″	3·4	23
Hazelside Douglas,	24″	42″	6·3	18
Achnacloich, - -	72″	82″	5·0	27

Wide differences appear to result through varying soil and climatic conditions, but the results are more apparent than real, since they may be explained as being largely due to differences in stage of growth, as it was unfortunately not possible to procure all the samples at the same stage of maturity. It would therefore appear justifiable to conclude that the age and the condition of the fronds—from exposure to rain at the time of cutting—explain to a very large extent the cause of the wide variation, in the published results, of the potash content of bracken ash.

Considering that kelp, which does not contain more than about 20 per cent. of potash, is used as a source of supply of this substance, the question of the utilisation of bracken for the same purpose is worthy of consideration. The yield and the amount of ash obtainable will largely determine this point. At Cleavance, on ground entirely occupied with bracken, the number of fronds amounted on an average to 30 to the square yard, and at Dundonald and Shewalton Moss to about 40. Using these figures as the basis of calculation, the quantity of ash and of potash obtainable works out as follows :—

Monthly Samplings, 1916.	Ash, lbs. per Acre.			Potash (K_2O), lbs. per Acre.		
	Dundonald Glen.	Shewalton Moss.	Cleavance.	Dundonald Glen.	Shewalton Moss.	Cleavance.
May, -	41	36	—	23	19	—
June, -	287	296	16	152	132	9
July, -	556	562	111	264	239	53
August, -	678	642	236	289	204	106
September,	601	403	323	225	88	130
October, -	186	132	193	40	13	20

Under ideal conditions of cutting, drying, and burning, the figures show that, with the more luxurious and vigorous growth at Dundonald Glen and Shewalton Moss, it required about four acres of fully-stocked bracken land to yield one ton of ash, while with the shorter and less dense growth at Cleavance it required about seven acres. This latter figure is representative of large stretches of bracken land in more or less exposed situations. A large yield of ash does not necessarily mean a richer ash, but, as the figures show, rather the reverse. The yields are in all probability a good deal higher than

would be attained in practice, as the incineration was performed with the minimum amount of loss. Some of the samples burned more readily than others, and a tendency to fuse was noticed in some of the samples containing the higher potash content. The breaking off of some of the pinnules or small leaves during the drying and handling of the bracken, though accounting for some loss, is otherwise of no disadvantage, since the pinnules were found to contain about 40 per cent., while the mid ribs and stems contained about 52 per cent. of potash in the ash. A loss of potash in the form of the chloride may occur by volatilisation caused by the high temperature sometimes reached when bracken is burnt in large heaps, besides the danger of the ash fusing into solid lumps.

The cutting can be done with a scythe or hook, by boy or woman labour. The bracken should, if necessary, be turned to facilitate its drying, and, when dry, raked into heaps. If situated on the side of a hill or in other inaccessible places, the dry bracken should be collected and burned at the most suitable spot, but if situated on the level it can be carted and stacked at a suitable place, and burned at a convenient time. The burning should be conducted in as sheltered a place as possible, to prevent some of the ashes being blown away. In any case, the dead and dry bracken or the ash must not on any account be left exposed to the leaching action of rain, which would dissolve out the soluble potash salts. The ashes should be bagged and placed in a dry place until required. If it is not possible to do this at once, the ashes should be covered with corrugated sheet-iron or tarpaulins to protect them from the rain. The time to cut and burn the bracken is when the maximum yield of potash can be secured. This will depend upon the district—whether it is early or late, sheltered or exposed—but the appearance of the fronds, such as the withering of some of the pinnules and when the green begins to give place to a yellowish colour in the stems, is the best indication. The percentage of potash in the ash at this time varied between 40 and 42·5 at the three centres

(see former tables). An ash containing 56 per cent. potash is equal to 82 per cent. when expressed as the carbonate. Such figures show a remarkably high concentration of potash salts. Except in the case of the dock, rhubarb, tomato, and bilberry plants, the writer is not aware of any other plants containing such a high proportion of potash salts in the ash.

With the market value of potash at 12s. 6d. per unit, one ton of ash, containing 40 per cent. of potash, is worth about £25. This figure, after allowing for considerable losses in the handling and burning of the bracken, and putting the cost of cutting, drying, stacking, and burning at £1 per acre, leaves a good margin of profit, independent of the enhanced value of the land by clearing off the bracken.

The ash, when properly burnt, is bulky and generally greyish in colour, of a light, friable, and powdery nature, and distinctly alkaline. The alkalinity is due mainly to alkaline carbonates, and, to a smaller extent, to lime and magnesia, the former amounting to about 10 per cent. and the latter 6 per cent. of the ash. However, apart from the effect of age, the proportion of these will alter according to their abundance or otherwise in the soil. The silica amounts to about 23 per cent. of the ash. The potash is in combination mostly as the sulphate and the chloride, and to a less extent as the carbonate, but the amount of sulphate and chloride present is more than sufficient to combine with the whole of the potash.

The sprinkling and mixing with the ash of sufficient sulphuric acid to just decompose the carbonates and neutralise the bases present, but without making the ashes unduly damp, would, by destroying their caustic nature, considerably improve them as a source of potash for immediate application to any crop. However, in inexperienced hands it would perhaps be unwise to recommend the adoption of this course. The crude ashes are suitable for mixing and applying with almost any manure, with the exception of those containing ammonium salts, which would be decomposed,

liberating ammonia. One ton of ash containing, say, 40 per cent. of potash, will obviously supply one-third more potash than that contained in one ton of 30 per cent. potash manure salts. Some allowance, however, must be made for the lower solubility of the former. As to the quantity of ash obtainable in Scotland, the writer is not aware of any data upon which even a rough estimate could be based, but whatever may be the amount which might be made available, it would seem unpardonable folly, in these times when potash salts are unprocurable in quantity, to remain indifferent to a source which, with a little trouble, can in many cases be secured close at hand. The phosphoric acid amounts to about 4 per cent. of the ash of the mature fronds, the presence of which is a considerable acquisition to the value of the ash as a manure.

A discovery of great scientific interest and of considerable economic importance has, within recent years, been made in North Africa, in Etruria, on the border of Abyssinia, where a deposit of about one million tons of almost pure muriate of potash has been found. This deposit has been purchased and is now being worked by a British syndicate.

USE OF DRY BRACKEN AS LITTER.

Besides being a source of potash, the dry bracken is valuable as litter. It contains about 2·5 to 3 per cent. nitrogen, between 2 and 3 per cent. of potash, and about 0·3 per cent. of phosphoric acid. In its absorbent properties it is superior to straw, though much inferior to peat in this respect. It should be cut when green and succulent, otherwise if the stems mature they become woody and hard for bedding purposes, and in addition they take longer to decompose in the soil. The trampling of the stems makes them more absorbent for liquids. The small leaves or pinnules are the more absorbent and readily decomposible part of the fronds, the proportion of stem amounting to about 60 per cent. of

the fronds. The percentage of dry matter and the yield of air-dry bracken at the three centres are given in the following table :—

Monthly Samplings, 1916.	Dry Matter in Fresh Bracken. Percentages.			Air-dry Bracken. Cwts. per Acre.		
	Dundonald Glen.	Shewalton Moss.	Cleavance.	Dundonald Glen.	Shewalton Moss.	Cleavance.
May, -	8·0	8·5	—	4·5	4·3	—
June, -	15·5	23·6	11·3	41·2	86·6	1·8
July,	21·5	27·4	23·9	90·5	119·0	19·9
August, -	26·1	31·2	28·9	110·6	153·0	38·5
September,	28·4	38·8	31·3	89·7	88·9	52·3
October, -	73·9	64·4	58·4	73·8	73·2	41·2

The percentage of dry matter increases with the age of the bracken. The maximum yield per acre of air-dry bracken varied from 52 cwts. to 153 cwts. at the three centres. The former figure is representative of large tracts of bracken land. Putting the young bracken at 25s. per ton of litter, and the mature bracken at 15s. per ton, the value per acre of fully stocked ground would therefore vary from about £2 10s. to £9 10s. for the former, and correspondingly less for the latter. The cost of cutting, drying, and stacking should not be more than 15s. per acre. The utilisation of bracken as litter should therefore be a profitable undertaking, apart from any other advantages from clearing the ground of one of the worst of pests.

The percentages of potash in the fresh and in the dry bracken, also in bracken ash, is given in the following table :—

	Percentages of Potash, K_2O in								
	Fresh Bracken.			Dry Bracken.			Bracken Ash.		
	Dundonald Glen.	Shewalton Moss.	Cleavance.	Dundonald Glen.	Shewalton Moss.	Cleavance.	Dundonald Glen.	Shewalton Moss.	Cleavance.
May, -	0·42	0·44	—	5·26	4·90	—	56	54	—
June, -	0·59	0·64	0·57	3·81	2·72	5·09	53	45	55
July, -	0·65	0·58	0·69	3·02	2·14	2·92	47	42	48
August, -	0·70	0·47	0·82	2·71	1·52	2·86	42	30	45
September,	0·64	0·39	0·80	2·27	1·03	2·57	37	22	40
October, -	0·56	0·19	0·27	0·77	0·31	0·49	21	10	10

MISCELLANEOUS USES OF BRACKEN.

The mature fronds can be used for the purpose of thatching, and for packing goods for transit. It contains tannic and gallic acids and for this reason it has been used as a substitute for hops and for dressing kid and chamois leather. It has also been tried for paper-making, but on account of the wastage in the preparation of the pulp compared with that of esparto grass its use is not recommended, besides, the frequent knots are a disadvantage. The young fronds are sometimes used as fodder, and the cattle pick them out from the litter, also in wet weather they can be made into silage in the same way as hay. It is, however, an advantage to chaff the fronds and mix them with an equal amount of cut straw. The silage obtained is said to be pleasant to smell, and is relished by stock. In Japan the fronds are prepared and eaten like asparagus, but their astringency is, perhaps, rather too pronounced for the ordinary palate. The analysis of the

dry matter of the young fronds, at the first cutting at Dundonald, in percentages, is—ash, 9·5; crude ether extract, 2·9; crude fibre, 13·5; crude protein, 27·8; and crude carbohydrates, 46·3. It is, therefore, a highly nutritious article of diet. Water formed over 90 per cent. of the fronds at this stage. Various medicinal virtues have been at one time or another attributed to bracken, particularly its vermifugal properties. The rhizome or root stock contains mucilage and starch, and in times of great distress and scarcity it has been ground and mixed with barley meal and used as a kind of bread. At Teneriffe it was important at one time as a food supply, and furnished the so-called Helecho bread. By roasting the rhizomes until the outer skin is charred, the fibres can be separated by beating, and the starchy substance which remains tastes much like oatcake. It possesses a slight astringency, and is said to be a wholesome food. The ash of the rhizome dug in October contains 10·3 per cent. of potash, an amount lower than was anticipated.

ERADICATION OF BRACKEN.

The utilisation of bracken serves two purposes. It not only provides some monetary return from the ground occupied by bracken, but it offers an opportunity of exterminating the pest. Hitherto practically the only serious attempt at the driving out of bracken or of keeping it in check has been to cut down the fronds with a scythe or hook, or to break them off by means of a switch or by chain harrows. By repeating the treatment for three years in succession land has been practically cleared of bracken. The fronds, in the course of their growth, manufacture food material, much of which is eventually stored up in the rhizome for the use of the growing buds in the following spring. By cutting the fronds at the time indicated previously, the root stock is largely deprived of the supply of this material. If the treatment is persisted in, the roots will in course of time die from exhaustion and starvation. Two cuttings during the summer may be more effective as a means

of eradication, but it adds to the cost of the material for economic purposes. The increased value of the cleared land for agricultural and afforestation purposes is of course a great asset in any scheme dealing with bracken, and in fact it is the main purpose for dealing with the pest. At Auchentorlie the cost of exterminating between 500 and 600 acres of bracken land was £350, and at Tighnabruaich it cost £190 to free 200 acres of bracken; a period of three years being required in each case. Spraying the fronds with solutions of sulphate of iron, sulphate of copper, dilute sulphuric acid, and hydrochloric acid, have been tried. Of these chemicals, it is reported that an 8 per cent. solution of sulphuric acid gives results which are promising, and the method is receiving further careful investigation. Applied at the rate of 40 gallons per acre would mean the addition of about 30 lbs. of sulphuric acid over an acre of ground.

In the coming summer it is intended to carry out further practical tests in the cutting and burning of bracken, and in its use as litter.

SUMMARY OF RESULTS.

The composition of bracken depends mainly upon the age of the fronds, and, to a less extent, to varying soil and climatic conditions.

The ash in the dry matter amounts to about 9 per cent., and contains 55 per cent. of potash in the young fronds, and to about 6 per cent. and 40 per cent. respectively in the mature fronds. The rate of fall varies according to soil and climatic conditions.

The potash in the ash is present largely as the sulphate and the chloride of potassium. Some carbonate is also present. Over 90 per cent. of the total potash, in carefully prepared ash, is soluble in water.

By extracting the dry matter with water, more than 90 per cent. of the total potash in the form of neutral salts is dissolved out, a fact which will largely account for the very low potash content of ash made from dead bracken, cut in the

winter months after exposure to the leaching action of rain. Age of the plant does not affect the solubility of the potash.

The caustic nature of the ash can be destroyed by the addition, in a fine state of division, of acid salts such as superphosphate of lime, or nitre cake (sodium hydrogen sulphate).

In the making of the ash, too large a fire should not be kept burning, otherwise a very high temperature may be attained, which might cause some loss by volatilisation of potassium in the form of the chloride, and also fusion of the ash into solid lumps.

The best time to cut the bracken to secure the greatest yield of potash is when the fronds have reached their maximum growth, a development indicated by the withering of some of the small leaves and when the green colour of the stem begins to change. The date will vary according to season and local conditions.

Under the best conditions of cutting, drying, and burning, it requires from 4 to about 8 acres—according to the density of growth and height of the fronds—of fully stocked bracken land to yield one ton of ash. With the price of potash at 12s. 6d. per unit, one ton of ash, containing 40 per cent. of potash, is worth about £25. After deducting the cost of the preparation of the ash, a good margin of profit, at the prices indicated, is left, irrespective of the enhanced value of the land.

The crude ash should be bagged and stored in a dry place until required. It can be mixed and applied along with most manures, except those containing ammonium salts.

The utilisation of bracken for litter at the present time will more than repay the cost of cutting, drying, &c., besides providing an opportunity for freeing the land of a great pest.

The miscellaneous uses of bracken are also considered.

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The West of Scotland Agricultural College.

DISCHARGED DISABLED SAILORS AND SOLDIERS:

TRAINING AND EMPLOYMENT IN RURAL OCCUPATIONS.

BY

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DISCHARGED DISABLED SAILORS AND SOLDIERS:

Training and Employment in Rural Occupations.

The din of battle is still in our ears. Signs of its ceasing are but remote. Every day takes further toll of the flower of our manhood, and increases the number of those who are maimed and wounded for life. The problem of the discharged sailor or soldier is already a difficult one to solve, and every week that elapses 'twixt now and victory will make it still more difficult.

To solve this problem, and solve it satisfactorily, is the nation's duty. These discharged disabled men have their lives to live, and no pension, however generous, could ever adequately recompense them for the sacrifice they have made on their country's behalf. It is beyond our power to do that, but it is left to us to prove that we at least appreciate their sacrifice, and to show our appreciation by doing all in our power to provide employment of a bright, healthy and congenial nature, as well as to train the disabled men for entering on such employment so that they may take it up with every prospect of success, and ultimately become engrossed in their work to such an extent that they may forget their disablement, and thus be enabled to live happy, contented and useful lives. We cannot do more than this, but should never rest content with doing less.

The problem of making suitable provision for discharged disabled sailors and soldiers is engaging the attention of men in very varied spheres at the present time. The matter has been frequently considered by the Governors of the West of Scotland Agricultural College, and they welcomed some time ago a generous grant—from a public-spirited gentleman who wishes to remain anonymous—which enabled them to offer a

prize for the most suggestive scheme for the training and employment, particularly in rural occupation, of discharged disabled sailors and soldiers.

The response to the advertisement which appeared announcing the above was on the whole gratifying, and eight schemes were received.

Three of the schemes submitted were considered particularly good, and it was decided to award a first prize of twelve guineas, and two second (equal) prizes of six guineas each.

The first prize was awarded to two brothers, Mr. Thomas Young, N.D.A., F.S.I., Edinburgh, and Mr. William Young, C.E., P.A.S.I., Hamilton, who submitted a joint-scheme, which has since been published by the authors.

The second (equal) prizes were awarded to Mr. John A. Carlyle, B.Sc., Arbroath, and Mr. John Cuthbertson, F.R.S.E., F.E.I.S., Kilmarnock.

Amongst the other schemes submitted there were several of a suggestive and helpful nature, but none were considered to be quite up to the standard of the first three. The leading papers had comparative little in common, the suggested solutions being for the most part on different lines.

In the next few pages an attempt is made to set forth the chief features of each of these schemes. The task is a somewhat difficult as well as a delicate one, and in undertaking it the writer craves the indulgence of those whose schemes come under review.

SCHEME BY THE MESSRS. YOUNG.

In their scheme the brothers Young aimed at making *immediate* provision for the employment of disabled men in rural occupations; but they had also in view the possible extension of the scheme, in order to provide employment for able-bodied men when such are discharged from the Forces. They aimed at evolving a scheme more or less general in its application, but one which in its working would make use of as many of the existing organisations as possible, so as to avoid the delay which might be occasioned if new legislative machinery were required.

In this scheme the regeneration of village life is put forward as the solution of the problem—

> "It is our view, therefore, that any scheme for the settling of disabled men in the country, to be successful or sufficiently comprehensive, *must have as an essential basis the regeneration of our present rural villages.*"

In support of this decision the authors point out that the majority of our villages are situated in what might be called the most favoured spots. Many are surrounded with good land, the rent of which does not exceed to any appreciable extent the average rent of similar land not so conveniently situated; while, on account of railway and road connections, transport facilities are generally good. Further, they consider that a solution on the lines indicated would greatly simplify such questions as provision of schools, churches, &c., medical and tradesmen services, gas and water supply.

They recognise the housing difficulty—an important feature in any scheme—but consider that suitable villages have many advantages in that respect. As a result of making a survey of several typical villages they found many unoccupied dwelling-houses which could be cheaply purchased, repaired, and made habitable. They also found a number of byres, stables, and other outbuildings which had fallen into disuse, but which could be utilised in connection with allotment or small holdings schemes.

The procedure proposed in initiating the scheme is discussed at considerable length, and one feature on which considerable stress is put is the preparation of a Memorandum for the guidance of all Local Authorities for the purpose of securing uniformity of action, and in order that all villages selected for the purposes of the scheme may fulfil a number of essential requirements. The Memorandum referred to would indicate the salient features which any scheme would be expected to possess, point out the range of possible and suitable occupations, and give an outline of a typical scheme showing the acreage of land required for allotments, &c., at each selected village.

When a village is selected under the scheme, plans must be prepared in order that regeneration and extension may proceed on systematic lines and according to preconceived ideas. A map, based on the Ordnance Survey, 25 inches to the mile, should show the position of any houses it is proposed to renovate and utilise as dwelling-houses, as well as the position of other buildings to be made use of in connection with allotments and small holdings. This map would also show what land could be purchased or leased for the purposes of the scheme, how the land available might be subdivided, and in what direction and manner an extension of the village might take place.

Another map, 6 inches to the mile, should indicate areas of suitable land, if any, within a reasonable distance of the village, and land capable of being reclaimed and put to good use. On it should be noted the distance from the village to any adjoining market towns, and also the existing transit facilities.

The powers of the Local Authorities are set forth in some detail, and the view is expressed that the legislative machinery as it stands is sufficient for putting the scheme into operation.

> "These extensive powers of Local Authorities appear to be sufficiently comprehensive to enable Local Authorities to make provision for the necessary houses and land for discharged sailors and soldiers."

It is pointed out by the authors that while the scheme, viewed from the standpoint of any Local Authority, would be but a comparatively small undertaking, the ultimate effect would be far reaching.

It is assumed that at least 80 suitable villages could be found in Scotland, and that 50 ex-service men could finally settle in each, provision thus being made for 4,000 men. On the same basis, it is expected that England and Wales would absorb about 20,000 men.

In putting the scheme into operation, the disabled men are to receive first consideration. On the assumption that, out of every 50 men proposed to be provided for in each village, 30 are disabled—15 married and 15 single—and 20 able-bodied

ex-service men, arrangements only require to be made for 30 men to begin with, and the authors are of opinion that provision of housing accommodation in selected villages for 15 families and boarding accommodation for 15 single men would present no serious difficulty.

The making of provision for 20 able-bodied ex-service men is not such an urgent matter; and if necessary the village could even be extended to absorb these. It is pointed out that the erection of the necessary housing might play a small part in the solution of the problem to be faced when war is over.

With regard to the employment of the men, it is suggested that provision should be made for (1) a number of small holdings, particularly for men with previous experience in agriculture; (2) a large number of allotments suitable for market-gardening, fruit-growing, bee-keeping, poultry-keeping, &c.; and (3) for various subsidiary rural occupations which might be set up.

The view is expressed that for the disabled men the size of the allotment might vary from a small plot of half an acre or less up to 3 acres, but that the majority of the allotments would be small. Intensive cultivation of the land convenient to the selected villages is what is aimed at in the scheme. It is estimated that $27\frac{1}{2}$ acres would provide scope for the 30 disabled men to be dealt with in each selected village.

The size of the allotments or small holdings for the 20 able-bodied men is put at an average of 5 acres, the total amount of land required for the settlement of these men being 100 acres.

In suggesting that, on the average, 5 acres would suffice for the able-bodied men, the authors assume that these men's services would be much in demand on the neighbouring farms.

For the successful working of the scheme the authors put a good deal of stress on the need for establishing in each village a central depôt. At first the depôt would be retained in the hands of the Local Authority, and put under the management of a capable man, who would be responsible for running the depôt, but who must also be qualified to give guidance and advice to the allotment-holders. They suggest that in connection with the central depôt there might be suitable work-

shops for carrying on such rural handicrafts as the scheme made provision for; also a labour bureau, an insurance system, an implement department. The central depôt would also make suitable provision for collection of produce from allotment and small holders, and for the disposal of same to the best advantage, and for providing seeds, artificial manures, feeding stuffs, &c., as required.

With regard to the training of the men, the authors take the view that each man would be established in the occupation he knew most about, or in which he was likely to become quickly efficient, and that consequently the training would present no great difficulty. In the actual training the depôt manager is expected to play a very important part, and also the staffs of the Agricultural College.

The provision of the additional houses required before the ex-service men can be absorbed under the scheme is fully considered. The authors point out that though much can be effected by altering, repairing, and adding to existing houses, that in itself is not sufficient, and that after the war something would require to be done to provide the necessary new housing. They do not approve of the use of wooden huts, but favour rather the erection of permanent buildings. Plans of suitable houses accompanied the original scheme submitted, also an illustration of what could be done in the way of altering and repairing old dwelling-houses.

In order to exemplify the working of the scheme, the authors give certain particulars regarding the village of Leuchars, in Fifeshire. The village represents the type that should be selected for the purposes of the scheme. The population is about 500, and while there are a few subsidiary occupations at present, and room for considerable development in that direction, the inhabitants are mainly dependent on agriculture.

The authors state that at the present time there are ten empty but habitable houses, and other two houses which could be made habitable at very little expense, as well as several more or less dilapidated houses which could be converted into stables, byres, workshops, &c.

On inquiry it was found that there would be no difficulty in boarding 15 or 20 single men in the village.

To further emphasise the suitability of this village for the purposes of the scheme, it is pointed out that the surrounding land is of excellent quality, the water supply ample, the climate good, and the railway facilities first class.

The scheme just briefly reviewed has many admirable features, not the least pleasing being the fact that it makes immediate provision for discharged disabled men, and undoubtedly regeneration of village life might play a very important part in the solution of the problem before us.

When you come face to face with the actual facts and the practical working of the scheme, is it not the case that too great a sacrifice is demanded for the sake of certain benefits, some of which are after all very doubtful benefits? For the disabled men the days of additional sacrifice should be over. No doubt a few empty houses may be habitable, or capable of being made so, but our discharged disabled men deserve something more than a house that is habitable.

There are great difficulties in the way, but they should be offered nothing less than a modern house, with all up-to-date sanitary conveniences, and the cost of transforming an old house—possibly without a damp course even—into a suitable *home* for a disabled man and his family will often be quite as great as the erection of a new building, and even then not nearly so satisfactory.

Then, again, if a man is to make the most of his allotment or small holding, it is a great disadvantage that his house and any outbuildings required are not on the ground, or at least adjacent to it. That, unfortunately, is not always possible in the village scheme, and minor industries like pig-keeping, poultry-keeping, &c., are bound to suffer. A man might wish to keep a cow, and the only house available as a byre might be a quarter of a mile from his dwelling-house. Cow-keeping under such conditions, while not impossible, would certainly be under very disadvantageous circumstances.

Further, is it not the case that the size of a man's allotment is likely to be determined even more by the limited amount of ground available than by the man's disablement?

Undoubtedly the size of the allotment should be according to the man's ability to utilise it successfully. For many forms of disablement light work of a nature such as is required in connection with poultry-keeping is likely to prove more suitable than vegetable-growing; but even in poultry-keeping there should always be ample room for extension as the men gain in experience, but in the village plan ground is limited and extension not likely to be so easily effected.

The problem of the discharged disabled man who happens to be single is even more difficult in some respects than that of the married man; but the boarding of these single men in the villages has little if anything in its favour. Lodgings are too often no better than they are called, and few disabled men would be likely to leave their fathers' homes, however humble, even for the very best a village scheme could offer. The strength of a nation is to be found in the homes of its people; and while the writer fully realises the difficulty in always providing a home, he has no hesitation in saying that such is the ideal to aim at.

The making of provision for able-bodied ex-service men is not such a vital matter at the present time, but what is suggested for these scarcely appears to be adequate. An average of 5 acres per man does not offer very much room for development unless the system of cultivation is very intensive, and the prospect of casual labour on adjoining farms is not sufficiently reassuring.

If these men are settled in the villages, the area of land available must of necessity be limited; but why settle these men in the villages when, by going further afield, there would be ample room for extension, and even a possible chance of letting a man have 50 acres in the event of him proving that he could successfully utilise them?

Provided ample and adequate provision is made for housing, the village plan may afford a fairly satisfactory solution when a large number of what the authors call subsidiary industries can be successfully established and run in connection with allotment schemes; but even in this connection it should be pointed out that the work the man will be capable of taking up will depend largely on nature of disablement, and this

limits the possibility of successfully utilising an allotment and at the same time finding further profitable employment at some subsidiary industry. Not only so, but this would make the training of the man still more difficult; and, as the matter stands, the provision made in the scheme for the training of the men does not impress one as being quite all that is required. It might prove sufficient for men who had previously a fair knowledge of the branch they desire to take up, but in the case of the totally inexperienced would be quite inadequate. The preliminary training of the men is likely to be an important factor in the future success of any scheme for the settling of the disabled men in rural occupations.

SCHEME BY MR. CARLYLE.

The author considers it essential that any general scheme for the training and employment of discharged disabled sailors and soldiers must be comprehensive in character and scope, so that it may suit the different powers of the men; be economic, so that it may find a permanent place in the social system, and entail the minimum of active competition in its working. The scheme put forward is developed as far as possible along these lines.

In the working out of the scheme the colony system of small holdings is favoured, and considerable stress is put on the need for selecting good sound agricultural land in close proximity to a good stable market-centre, in order that the success of the scheme may be assured.

It is suggested that the necessary land be acquired by gift, by grant, or by purchase. In view of the great advantage that would accrue from single control and entire freedom of action, taking the required land on lease is not considered nearly so satisfactory.

The author favours acquiring the land in large blocks, to be divided into farms of 150 to 600 acres according to the rural occupations to be set up and the activities of the men to be placed thereon. These divisions are referred to as divisional centres, and each one is in reality equivalent to a fully-equipped, fully-staffed farm, with dwelling-house, steading, machinery, stock, &c.

These divisional centres are at first to be the training centres where the men are to be instructed in the departments of small farming for which they are fitted. Later these divisional centres are to absorb a group of small holders, and become, in part, a centre for intensive cultivation.

The preliminary training is divided into theoretical and practical, and it is suggested that the former be given by the College staffs, and the latter by a competent farm manager in charge of the divisional centre. The training of the men and the preparation of their holdings are to proceed simultaneously. A minimum of preliminary training with subsequent efficient advice and guidance is aimed at. The men would actually be in possession of their holding ere their training was completed.

The scheme proper is really intended to deal with the disabled men between two extremes. On the one hand, there are totally disabled men who cannot very well be provided for in a scheme of this kind. On the other hand, there are those, previously skilled in agriculture, who are only very slightly disabled, and who, by reason of the help they can obtain or of their own position, are able to take over the full management of a small holding right away.

It is the men between these extremes with whom the scheme is really concerned. They will, for the most part, be fitted for work of some kind; but no single type of occupation would suit all cases, and in the divisional centre holdings of different kinds must be set up in order to meet a wide variety of disablements. Vegetable-growing, flower-growing, fruit-farming, bee-keeping, poultry-keeping, cow-keeping, &c., are suggested as suitable branches.

In the working of the scheme there would be two groups of men to deal with, namely, the married men who are in a position to take up house, and the single men.

The married men, after a short period of preliminary training, would be given a house, but the single men would live together at the divisional centre.

It is pointed out that substantial wooden buildings, made with material at present utilised for huts for soldiers in training, would serve for the accommodation of the men during the

period of preliminary training, and later these buildings might serve as the permanent residence of the single men.

In the working of the scheme, as soon as a married man had received a certain amount of preliminary training he would be provided with a holding of his own, suitable for the branch he was best fitted for and purposed taking up. This holding would have a dwelling-house, a garden, and any equipment required, such as outbuildings, &c. The author favours the use of timber for the greater part of the buildings.

All buildings would be arranged in as orderly a manner as possible, so that the minimum of land would be taken up for roads, &c.

When the married men were settled the scheme would come fully into operation, as the buildings, land, &c., used in training these men would now be available for the single men.

> "Each married man would now have his own homestead. Each one would have full control of his holding, and with, at the beginning, expert advice and practical oversight would have full scope for his energy and enterprise."

The land at the divisional centre not taken up by the small holdings would be cultivated by the divisional centre staff on regular rotation lines, according to the district and the requirements of the small holders settled at the divisional centre. The small holders would get from the centre what farm produce, grain, fodder, roots, &c., they required at cost of production, which would be considerably below that at which they themselves could raise similar farm produce. Grazing for the cows and other stock would be provided by the centre at a certain rate per head. Any seeds, manures, feeding stuffs, &c., required by the small holder would also be provided by the divisional centre. This arrangement cheapens production, and also leaves the small holder free to give more attention to the special branch or branches he has taken up.

Disposal of produce would be by co-operative selling, which would embrace all the divisional centres in the district. Collection and transport of the produce to rail or market would be undertaken by the divisional centre staff, and charged for at actual cost.

As the scheme develops it is suggested that each divisional centre would resolve itself into an economic unit, with a competent manager and a committee of management popularly elected from the small holders in the centre.

The author points out that the final placing of the single men not in a position to take up house could not be on quite the same lines as the married men. They would reside in the large building already referred to, a certain amount of privacy being secured for the men by the provision of separate bedrooms. Otherwise they would be dealt with on the same lines as the married men. Each man, if he desired it, would be provided with land, buildings, and other equipment necessary for the occupation he purposes taking up; but as the men will be living together, it is suggested that those similarly disabled might co-operate in the occupation they were best fitted for.

The single men would have exactly the same rights in the divisional centre as regards co-operative selling, &c., as the married men.

With regard to the initiation and financing of the scheme, it is suggested that the Government should purchase the land, and hand it over to the body of management—which might very well be a Government department—responsible for carrying out the scheme.

The purchase of the land would be looked upon as the first capital expenditure. The cost of equipping the divisional centre and all the small holdings thereon would represent the second capital expenditure, and might be made up by gifts, grants, or even from a Government loan.

The rent of each small holding might at first be just equivalent to the interest on the equipment money or second capital expenditure. Ultimately a scale of rents might be fixed according to the occupations followed, as in arranging the holdings in the divisional centre the land most suitable for the different branches of small farming would, as far as possible, be utilised accordingly.

In this scheme, the great need for which is confined to a single generation, the land remains the property of the State, and does not pass to the holder or his dependents.

In the working of the scheme there are many details and possible developments which could only be briefly referred to, but which merit fuller consideration; but the author's chief aim was to give a general idea of the working of the scheme, and in this he succeeded admirably.

The scheme put forward by Mr. Carlyle differs in many important features from the village plan previously considered, and in some respects it impresses one even more favourably on account of its great possibilities. In the solution of the problem before us there is a place for a scheme on the general lines considered.

If one might refer to the arrangements for preliminary training, these, as in the first scheme, are perhaps a little weak, especially in view of the fact that many of the discharged men will probably be quite inexperienced.

To equip a divisional centre in such a way as to be able to give even a good practical training in the many branches of small farming proposed to be dealt with is no easy matter. Take bee-keeping, poultry-keeping, pig-breeding and feeding and market gardening as examples, and think of the difficulties and all that is involved.

It would be a great mistake to attempt to give anything but the minimum of training essential for acquiring a good working knowledge before settling the men, but that minimum of training should be given; and the writer believes that even a day amongst different makes of incubators and other poultry appliances at a recognised training centre might often be of more value than a week's training at a divisional centre. It is possible to equip fully one or two training centres, but even to equip partially ten or twelve divisional centres could only be effected at very great cost.

The method of settling the married men has a great deal in its favour, but the suggestion to make extensive use of wood in the erection of the necessary buildings is of doubtful wisdom, especially in the case of the married men.

We want to get the people back to the land, and keep them and their families on the land when we get them there, and

good housing is one thing we must have ere we can hope to effect that happy result. Wooden houses can be made very comfortable, and in normal times can be erected comparatively cheaply, but we require something of a more enduring nature.

As in the last scheme the provision made for the single men still leaves much to be desired. The system suggested is very good, and would serve admirably for a short period, but the prospect of a lifetime of it would be anything but encouraging. If it were the author's intention to make such provision for the housing of the single men as would be effective in making them realise the benefits of, and perhaps encourage them towards, matrimony, he is to be heartily congratulated on the soundness of the plan adopted.

The cost of equipment in the way of dwelling-houses, outbuildings, &c., in a scheme of this kind is bound to be somewhat heavy, as everything has to be provided, but it is a great advantage to start perfectly free and untrammelled by existing buildings.

SCHEME BY MR. CUTHBERTSON.

This scheme is drafted on very broad general lines, and though it does not put forward the same concrete kind of proposal, it is in very many respects even more suggestive than either of the foregoing. The author, who very appropriately writes under the *nom de plume* of "Roadmender," states the case thus in somewhat poetic, but singularly lucid, language :—

> "Many of our discharged disabled sailors and soldiers are young men. They have their lives still to lead. Before them lies the long grey road. It will be ours to make the road as smooth and easy as possible, to provide shady nooks by the way, and sunny places for the war-worn men. Back from the war will come the blind, the halt, the lame, the broken in spirit, and ours will be the work of road-menders."

It is in this spirit that the author of the scheme tackles the problem before him. He points out that while Government will meet the more elemental needs of the men by pensions and

allowances, it is in the interest of the man's physical, intellectual, and moral well-being, as well as for the nation's good, that he be fitted, as far as that is possible, to earn at least part of his living.

The whole field is surveyed, and the problem is shown to be one with three quite distinct phases.

To begin with, it will be necessary in many cases to restore the faith of the disabled men in themselves. They have to be won back to cheerfulness, and shown that the outlook is really not as black as it appears to be. "Roadmender" takes the view that what is wanted here is light congenial employment as a curative and health-restoring agent, and that it matters very little what occupation is followed at first, provided the work suits the man's disablement and is both light and interesting.

The real difficulties of the problem arise in the second phase, which begins when health is restored and hope revived; and from experience "Roadmender" is able to show that the difficulties are very real indeed. In a number of actual cases put forward each man would seem to have suffered in his most vulnerable part, and to have been rendered quite unfit for his former work.

Undoubtedly the form of disablement will greatly limit the range of occupations which a man will be able to follow, while previous education and personal inclination will still further reduce the range. But it is pointed out that, even apart from this, there are difficulties on the economic side. The disabled men must not be put into occupations in which they will be competing with their countrymen, unless the selected occupations afford ample scope for all.

"Roadmender" then goes on to consider the occupations in which additional men could be employed, particularly for the production of commodities at present partly imported, but which could be produced at home. The possibilities are shown to be very great, in view of the enormous import of such products as honey, eggs, butter, cheese, fruit, flowers, vegetables, cereals, timber, &c. There is undoubtedly a wide and varied field for employment, and great need for development of the industries from which the products referred to are obtained.

"Small holdings might be developed, and some land at present not fully utilised could be brought into cultivation and other areas more intensively cultivated. There are, for example, straths in the Highlands, rough pastures and bog land in the Lowlands, and stretches near the sea which could be brought into fuller use, and there are great tracts of railway embankments where brambles, logan berries, and rasps could be grown. Poultry-keeping and bee-keeping could be commenced either in conjunction with general agriculture or alone. Fruit and vegetable culture could be increased. The need for home-grown timber has been vividly brought home to many minds, and the afforestation of suitable areas would give occupation to many men, either as sole occupation or conjointly with the working of small holdings. Peasant pottery, wood-carving, lace-making, knitting and weaving, and toy-making could also be followed either as independent occupations or as subsidiary occupations during the long winter evening."

The next difficulty that occurs is in connection with the training of the discharged disabled men. How are they to acquire a knowledge of the occupation they desire to follow? "Road-mender" points out that there are several possible methods; for example, the method of apprenticeship might be adopted, and the men "apprenticed" to those with special knowledge of the branch they desire to follow. On the other hand, they might be gathered for training at our agricultural colleges, college farms, dairy schools, poultry schools, apiaries, or, if a training is desired in artistic work, at our schools of art. But even these methods might not suffice, and probably it would be advisable to make arrangements in some districts for special schools of instruction, to be conducted by the staffs of the colleges or by men specially selected for the work. Provision for forestry education could best be made by beginning the much-needed afforestation of the country.

The third and final phase is in connection with the settling of the men in the occupations they have decided to follow.

Some men, particularly of the "apprenticed" class, will decide to remain as employees. Others may do so until such time as they are able to start on their own account. In most

cases financial assistance will be necessary to give the men a good start, and the most likely sources will be the State, public funds, or private donations.

"Roadmender" then goes on to show the amount of capital that will be necessary to give the men a fair start in certain typical employments, as well as to indicate the probable return for the capital invested.

Bee-keeping, poultry-keeping, market-gardening, and certain types of small holdings are dealt with in detail, and particulars and costs of equipment given. The great aim is to give the man a sufficiently good start to enable him to earn such a sum as will, with his pension, prove sufficient to keep his family and himself in comfort.

The possibilities of peasant pottery are briefly considered, and it is pointed out that many coloured vases were imported from the Continent in recent years, and that while the raw material costs at most a few pence, the vases sell at several shillings each. In many districts in Scotland there is plenty of suitable clay for such work. Manufacture by hand or wheel is simple, though it requires taste. Glazes are cheap, and the necessary kiln for firing can be purchased for a few pounds.

The equipment required in connection with toy-making is also very simple. Toys of a substantial nature are what are wanted, rather than the showy, flimsy, mechanical type formerly imported from Germany, and which lasted for about a day.

These and other similar minor industries, such as wood-carving, lace-making, weaving, &c., might well be the means of providing much useful and remunerative employment for disabled men.

The actual method of settling the men on the land then comes up for consideration, and while "Roadmender" does not put forward any single concrete scheme, he discusses various alternatives and their possibilities, such as the establishment, in suitable districts convenient to a good market or railway centre, of colonies of small holders, to be run on co-operative lines, particularly as regards purchase of seeds, manures, feeding stuffs, &c., and the sale of produce. An adviser is either to be stationed at the centre or to make periodic visits. It is suggested that such a place might be made self-supporting,

if care is exercised in setting up only the most suitable occupations.

Then, again, there are isolated spots where certain occupations could be commenced, and there is also the possibility of settling the men in the rural villages. In the latter connection it is pointed out that, even at the present time, there are in many villages houses available which could, at little cost, be made comfortable, and that the isolation of certain villages will not be such a drawback in the future, as even the most remote villages could easily be linked up with the busier centres by motor transport.

The possibility of utilising wooden huts for temporary housing purposes or for subsidiary buildings is also noted.

The method of acquiring the land needed for the purposes of the scheme is not dealt with, beyond pointing out that some of our large landowners are likely to be willing to give land free or at nominal rent.

> "They give their sons in the war. They will be willing to assist the men who fought and bled side by side with their own boys."

The capital required to set up the men who have proved their ability in the occupations they intend to follow should, according to "Roadmender," be provided by Government by way of a loan, or by grants from patriotic funds. Repayment should be spread over a considerable period of years, but no repayment should be required for the first three years. After that the man will, in a sense, have "found his feet," and be able to repay £5 annually. Every £5 repaid should be reckoned as £10, so that the man is entirely free when he has repaid half the amount of the original capital granted.

The Government should have a lien on the property, but it is pointed out that legislation might be necessary to secure this.

"Roadmender" points out that while the provision of the necessary capital would form a considerable burden on the State, our indebtedness to these men demands it, and for that reason, coupled with the fact that the families of these men would provide a new source of rural labour, and thus tend to

increase the total value of the nation's wealth, the making of provision on the lines indicated is more than justified.

The scheme by "Roadmender" is drafted on slightly different lines from the two schemes already considered, being on the whole suggestive rather than concrete. It therefore does not lend itself so readily to criticism.

From actual experience of the type of men to be provided for, "Roadmender" realises the difficulties that must be overcome before the men can be happily settled in rural occupations. Most people will agree with him as to the part that light congenial employment may play as a curative agent; in fact, the importance of this has been frequently demonstrated. The provision of suitable employment at the right time, in addition to restoring health and hope, is likely to be the means of ultimately winning many men for rural occupations. Of those formerly employed in factories, shops, offices, &c., in our cities few realise what an outdoor life means, and once they taste its pleasures they will, in many cases, be reluctant to resume indoor occupations.

It is in the second phase, particularly in determining the most suitable occupation for the man, and in training and fitting him for it, that the greatest difficulty will arise, but when the individual cases are considered it will frequently be found that there are factors which greatly restrict choice of suitable occupations.

There is not enough said regarding the method of training to enable one to judge as to whether the provision made in this scheme is ample or not. Preliminary training is essential, but should be of as practical a nature as is consistent with efficiency, as that mode of training will appeal more to the men.

With regard to the provision of suitable land on which to settle the men, it would scarcely do to rely entirely on the generosity of landowners, as that is not likely fully to meet the case. A very considerable area of land may be offered for small holdings or other purposes, but the ultimate success of small holdings schemes will depend largely on the nature of the land that is available, its position relative to a good

market centre, and the prevailing climatic conditions. If a man desires to take a small holding for stock-rearing, and combines this industry with forest work, nature of soil and climate and convenience to a good market centre are of less importance than they would be if he wished to take up market gardening.

There is a very great deal in favour of the method of repayment of capital suggested. It will encourage thrift on the part of the men, retain and foster a spirit of independence—which is, unfortunately, all too rare at the present day—and at the same time give just the right amount of encouragement.

TRAINING AND EMPLOYMENT.

Before considering the problem further it is almost necessary to have more clearly before us certain features which are bound to have a very marked effect in determining the rural occupation that will ultimately be followed by any disabled man. A Memorandum on the training of discharged disabled sailors and soldiers, with a view to their employment in rural occupations, was recently prepared by the writer for the consideration of the Governors of the College he has the honour of representing, and as this Memorandum bears very distinctly on the whole subject, and deals with certain limiting factors that must be considered, as well as with the making of suitable provision for training, it has been thought advisable to include a considerable section of the Memorandum in this Report. It may, to some extent at least, help to bring to a focus certain matters briefly dealt with in one or other of the foregoing schemes :—

MEMORANDUM ON THE TRAINING OF DISCHARGED DISABLED SAILORS AND SOLDIERS, WITH A VIEW TO THEIR EMPLOYMENT IN RURAL OCCUPATIONS.

Limiting Factors.

In dealing with this subject the following important considerations should be kept in view, as they are bound to act

as "limiting factors" in any scheme for the training and employment of the disabled :—

(1) The Nature of the Man's Disablement.

The ultimate fitness of any discharged disabled sailor or soldier for one or other of the possible rural occupations will depend to a very great extent on the nature of his disablement. A man minus an arm would be very severely handicapped in practical market-gardening, but the handicap would not be nearly so severe in such industries as poultry-keeping or bee-keeping.

The ideal, from the economic point of view, would be to place each man in the sphere in which his disablement would be least felt, so that his earning capacity might be as little impaired as possible. This, though no doubt very desirable, cannot be generally followed, as nature of disablement is after all only one of the limiting factors.

(2) The Natural Preference of the Discharged Disabled Man.

If the men are to be happily and contentedly settled, their occupation must, in the first place, provide work of a congenial nature. If a man's heart is not in his work, he will neither do justice to himself nor to his work. It is, therefore, of the very greatest importance that the natural preference of each individual be met as far as that is possible.

(3) Previous Education and Experience.

Previous education and experience also call for consideration, because, apart from nature of disablement and natural preference, a man's fitness for any particular sphere is largely dependent thereon. If he is not equipped in that respect for the work he desires to take up, he must be given ample opportunity of equipping himself by such theoretical and practical training as is essential for success.

(4) Financial Position of the Man and the Support he can rely on.

Another important consideration is the financial position of the man—apart altogether from his earning capacity—and the

support and practical assistance he is likely to receive from his relatives, personal friends, or others who may see fit to take an interest in his welfare.

It is almost certain that the great majority of the disabled men who desire to follow rural occupations will require very substantial financial assistance if they are to get a sufficiently good start to ensure a reasonable measure of success.

Certain prominent individuals who have this matter very much at heart have made offers of financial help to assist in placing a few selected and deserving men when their training is complete, but individual effort, no matter how praiseworthy, is not likely to provide sufficient funds for placing more than a comparatively small percentage of the men who will require help, so that some Government assistance is likely to be an essential in any comprehensive scheme for the training of discharged sailors and soldiers and settlement in rural occupations.

Some Suitable Rural Occupations.

Of the different rural occupations the following have been selected :—

(1) Because they afford a wide variety of occupations suitable for discharged disabled men of very different degrees of disablement. The case of the severely disabled is met as well as that of the man who is almost wholly fit.

(2) Because they are occupations in which there is very great room for development without in any way hurting existing similar industries.

(3) Because, with one exception, they are rural occupations, for which suitable training can be provided by this College.

Bee-Keeping.

This is one of the minor industries suitable for all classes, but likely to appeal specially to the more severely disabled in that it affords light interesting work, and at the same time gives a very remunerative as well as a quick return for the amount of capital required. Even for the man totally ignorant of the subject, all the instruction necessary (theoretical and

practical) to enable him to acquire a fair working knowledge could be given in a course of four weeks' duration. In view of the fact that an apiary was recently established at the College farm, the present equipment is sufficient for the needs of such a course. The summer months are most suitable for giving instruction in this subject.

Poultry-Keeping.

This is an industry in which there is great room as well as great need for development, and it is one in which men suffering from various disablements might find useful, congenial, and remunerative employment. The work is not heavy, unless where taken up on an extensive scale, and, as in the case of bee-keeping, the return for the amount of capital required is entirely satisfactory, provided the system of management is good. We have ample evidence of this from our poultry demonstration crofts.

A course of ten weeks' duration would be quite sufficient to enable a student to acquire a good general working knowledge of the subject. Such a course might begin at almost any period of the year, but experience in hatching and in the rearing of the young birds can best be obtained in the spring and early summer months.

The poultry department at Kilmarnock is at present sufficiently well equipped to provide fully for the requirements of such a course.

Pig-Feeding.

As in the case of poultry keeping, there is not only room but also great need for development in this department. The breeding and fattening of pigs is work that many men, too severely disabled to engage in several other occupations, might with advantage turn their attention to, provided they have a liking for work amongst this class of stock.

Frequently the return in fattening pigs is not altogether satisfactory, particularly if the feeder is not also the breeder; young store pigs often command such a high market price that there is little room for profit. When the feeder is also

the breeder the return from the fattening of pigs is much more certain.

The chances of making pig-breeding and feeding a profitable employment are much greater when it is combined with such work as vegetable culture, as any surplus produce, small potatoes, &c., can be turned to good account in the feeding of the pigs, while the manure produced is very valuable for use on the land.

A practical knowledge of the breeding, feeding, and general management of pigs could be acquired at the College farm, as a number of good breeding sows and fattening pigs are always kept there. The course of training in this branch should be mainly of a practical nature, and of not less than ten weeks' duration.

Vegetable, Fruit, and Flower Culture.

This is another rural occupation which, as our annual imports of vegetables, fruit, and flowers show, might with considerable benefit to the country be more widely engaged in. In itself it affords great variety of employment, but it is not likely to appeal to quite so many discharged disabled men as the minor industries already referred to.

In vegetable culture particularly there is a good deal of fairly heavy manual work required, and many men, on account of the nature of this disablement, would not be fit for this, but, on the other hand, those who are fit, and who already have, or take steps to acquire, the necessary knowledge, are likely to find ample scope for their energies therein.

Considerable capital is necessary to give a man a good start, as in the raising of such crops as tomatoes "glass" is essential; but with a suitable and convenient market the return is likely to be very good, though there is always a certain amount of risk to face, as much of the produce raised is of a very perishable nature.

Suitable training for those who desire to engage in work of this kind can be provided by the horticultural department. The course of training should be for the most part of a practical nature, and of not less than six months' duration, and commence preferably in the month of April.

Branches of Dairying.

(a) *Milk Recording.*—There are a considerable number of openings in this line, and there is good reason to believe that dairy farmers are now more fully alive to the benefits from systematic milk recording, and that consequently a greatly increased number of recorders will be required.

The work is likely to appeal most to the younger men because of the constant moving from place to place involved in milk recording. Older men would find it rather trying.

To be fit for a post as a milk recorder a man needs to be naturally intelligent, be gifted with good eyesight, even though it be only from one eye, have the full use of both hands, and be fairly active. Quite a number of young disabled men are likely to fulfil these requirements, and to such milk recording offers useful, instructive, and remunerative employment.

It has the further advantage that the necessary knowledge can be acquired in a course of training of three or four weeks' duration. The training of milk recorders is part of the regular work of the dairy department, and the College herd of dairy cows provides ample opportunity for demonstration and practice. The provision of suitable training for those who may desire to take up this work, therefore, presents no difficulty.

(b) *The Manufacture of Butter and Cheese.*—There is perhaps not the same scope here as in some other directions, but still there is room for any who may evince a natural preference for work of this kind.

To successfully engage in it a man must not be too severely disabled, as there is a good deal of heavy lifting involved, particularly in cheese-making when carried on in an extensive scale.

The dairy school and College farm at Kilmarnock afford facilities which make it possible to give a specially good practical training in these branches of dairying, as well as in the general handling of milk.

The duration of the course that would be necessary depends in great measure on the previous experience of the men. When practically ignorant of the subject four weeks would be needed

to acquire a good experience and knowledge of butter-making, but in cheese-making, on account of the slow ripening of the product, a six months' course would be advisable.

Nursery and General Forest Work.

This is another possible and, in many respects, a suitable rural occupation, but, unfortunately, a full practical training in this work could not at present be given at the College farm. There are, however, extensive nurseries close at hand, and arrangements might be made which would enable disabled men who prefer and are fitted for work of this kind to obtain a sound knowledge of nursery work.

For planting under forest conditions, for experience in felling and handling timber, and in sawmill work, some other arrangement would require to be made.

Forestry is very important, as work in a forest might often with advantage be taken up in conjunction with a small holding. The forest would provide remunerative employment during the winter months when the work on the holding was light, but this branch need not be considered except in relation to those who are only very slightly disabled, as there is a good deal of heavy work involved.

Employment as Small Holders.

There are great possibilities here for such of our disabled men as desire to settle on the land. A small holding can be successfully developed in entirely different ways, and may thus be made to provide a variety of employment to suit the nature of the disablement.

Those who by reason of their disablement are not fit for much heavy physical work might have their holding almost all in grass, only cultivating a small plot for the production of potatoes and other vegetables for table use. They might keep two or more cows, according to the extent of the holding, sell whole milk if there is a convenient market, or make butter or small-holders' cheese, and rear calves. Part of the grass land would need to be reserved for hay to produce fodder for winter.

In addition, but without interfering with the system of working the holding, any of the minor industries already referred to might be developed, particularly bee-keeping, poultry-keeping, but also pig-breeding and feeding, and vegetable culture, according to the fitness of the man. Where the small holders were fit for heavier physical work the cultivation might be much more intensive, and a variety of crops raised either for sale or for consumption by stock kept on the holding, or for both purposes.

Training of men as small holders can also be provided at the College farm, but in order to make this more complete, and demonstrate better the possibilities in a small holding, *8 to 10 acres* of land should be set apart and utilised as a model holding. At comparatively small expense houses could be erected to serve as byre, piggery, poultry-house, barn, store, &c. A cottage is not essential, but an office would be a convenience. The necessary stock—cows, poultry, pigs—could be taken from the stock on the farm.

Careful records could be kept showing such things as cost of feeding and returns obtained from cows, poultry, pigs, &c.

A model holding of this type would be of very great value in fitting men for employment as small holders. It is not so much required for the actual training as to show how a knowledge acquired in the different departments—dairy, poultry, &c.—could be turned to best advantage under the limitations of a small holding, and it is rather from this point of view that so much stress is put on the need for a model holding.

The course of training for those who are inexperienced, and who desire to settle ultimately as small holders, would require to be of not less than a year's duration, as the knowledge required is wide and varied. The instruction should be of as practical a nature as possible by actual demonstration and otherwise, but a considerable amount of theoretical instruction would also be essential.

In other quarters an attempt—apparently meeting with a good deal of success—is being made to revive the hand-loom industry, and though it is perhaps a little outside the province of an Agricultural College, this might be introduced for dis-

abled men unable to move afield and fit only for very light work. The same would apply to basket-making and all useful work of that kind.

It is very probable that some of the men who are not very severely disabled may desire to become county agricultural instructors, or qualify for posts of a similar nature. If such men have a good knowledge of practical agriculture, and take the full three or four years' course of training provided by the College, their services might be turned to good account in further developing the agriculture of this country.

It will be seen that no suggestion has been put forward in the Memorandum for the training of disabled men with a view to providing a source of farm labour. In the first place, that is not likely to be the most suitable class of work for disabled men. Even where nature of disablement does not interfere with their fitness for such work, it is not to be indiscriminately recommended, as farm labour, as we ordinarily understand the term, is not particularly inviting, and the disabled men should be offered something more promising and of a more settled nature. No doubt some men might be successfully employed as shepherds and in the feeding and tending of cattle and similar work. In view also of the great strides that have recently been made in connection with motor cultivation, and the part that this is likely to play in the agriculture of the future, there are certain to be openings, on the larger farms particularly, for a considerable number of men with a knowledge of motor mechanics as applied to agriculture. The possibility of disabled men taking up this branch will depend, amongst other things, on nature of disablement, but such as are fitted for it should be encouraged to take it up.

This war has forced us to realise, perhaps better than anything else, our dependence on the land.

A country so far from being self-supporting as ours is greatly handicapped in time of war, and when the present struggle is over there is likely to be a clear call for the revival of agriculture and the development of all rural occupations. We must not forget, however, that farming, whether carried out

on a large or a small scale, is a highly technical business, and considerable stress should be put on the re-education, where necessary, of the disabled men in the new branches they decide to take up. The writer believes that the training can best be given along the lines generally indicated in the foregoing Memorandum.

In the long run training is likely to be as important a factor as any in determining the success or failure of the venture. We want these men ultimately to be in such a position as to secure for themselves the "glorious privilege of being independent," and the provision of suitable training will go far towards enabling them to do so.

Whether the training should be provided before the men are discharged, that is, while they are still subject to military discipline, as is advocated in France, is a matter that would need very careful consideration. On the whole that would seem to be the better method, as when the men cease to be soldiers the great desire of many will be to get home and remain there, even though they only drift afterwards. It would undoubtedly be short-sighted policy on the part of the men, but the desire is a very natural one.

Even when preliminary training is over much will require to be done in the way of giving advice and guidance to the disabled men in their different spheres. This could best be accomplished by increasing the Extension staffs of the Colleges, so that the services of experts on agriculture, dairying, pig-keeping, market-gardening, poultry-keeping, and bee-keeping might be available as required.

Disabled men who have been brought up on the land, and those with a kind of natural aptitude and preference for work of a rural nature, are likely to succeed best in the various branches of small farming.

In any scheme for the training and settlement of the men in rural occupations steps should be taken, when bringing it to the notice of the disabled men, to make it appear as attractive as possible. The offer of training should carry with it the immediate prospect of settlement, as it is only likely to prove attractive in so far as it does so. Attention should be drawn to the scope afforded by the different rural

occupations; and their peculiar attractions, viewed from the standpoint of a disabled man fond of country life, should be clearly set forth.

With regard to the placing of the men, it is scarcely necessary to point out that the land is our greatest national asset, and as such should be utilised to much better advantage than has been the case in the past.

Successful settlement of our disabled men on the land would not only be greatly in the interests of the men themselves—and that, of course, is the first consideration, as we wish to see them happily settled—but in the long run it would be of inestimable benefit to the nation as a whole.

Even apart from the increased output of certain products—honey, eggs, vegetables, fruit, &c.—which we might reasonably expect if disabled men were settled in the different rural occupations for which they were best fitted, there would be another and even a more important benefit in that those born and brought up in the country contribute in a very marked degree to the stability and strength of a nation. Our first concern is for the disabled men; but in the interests of future national welfare the scheme for settlement should be of such a nature that while it makes ample provision for such of the disabled as desire to follow a rural calling, it will also tend to keep their families on the land. Much has been said about getting the people "back to the land," but the writer firmly believes that we will not get very many of the present generation to leave our cities and take up rural occupations, and that almost the only way to achieve what we so much desire is to begin by making conditions and prospects in the country sufficiently attractive to overcome what has aptly been described as the "lure of the city," so that those born and brought up in the country will, for the most part, be content to remain there. We have an opportunity of beginning now in arranging for the settlement of the disabled, and the opportunity should not be missed.

Some Suggestions as to Settlement.

The schemes previously dealt with may be taken as contributing essential parts of a single comprehensive scheme,

sufficiently varied in its nature to admit of suitable provision being made for almost all disabled men, except those totally incapacitated, who may desire to settle in rural occupations. *The regeneration of our villages, the establishing of colonies of small holders, the setting up of isolated holdings, and the revival of a number of subsidiary rural industries, as well as the development of new industries,* may all play a useful part in the solution of the problem.

On the whole, our rural villages are likely to contribute most effectively through the development of such rural industries as may be suitable for each particular village, and by the provision of allotments mainly for the production of vegetables and fruit.

The village scheme is not ideal for the setting up of small holdings, but, in addition to the provision of allotments, it may be possible to arrange for a limited number on which cow-keeping, poultry-keeping, &c., could be taken up. In doing so empty buildings should only be utilised in so far as they can be made quite suitable both from point of view of construction and situation. The cottage and outbuildings required must be convenient to each other, and situated on or at least adjacent to the land that is to form the small holding.

This arrangement will seldom be possible if existing buildings are to be utilised, and, in spite of the greater cost, it will generally be much more satisfactory to extend the village and erect new and suitable buildings on the land allotted. In addition to other advantages that would accrue, provision could be made much more easily for enlarging the holding if that were ever required.

One great advantage of a small holding lies in the fact that it can be successfully developed in a great variety of ways, and may thus prove quite suitable for men suffering from different forms of disablement.

The actual development of the holding will depend a good deal, apart from the personal equation, on the assistance the disabled man can get in his own family. He may have lost a hand, and thus be unable to milk; but if married, his wife or some member of the family might be able to attend to that; or if single, perhaps his mother or a sister; and in this way

dairying would be possible even for the man with one hand. The want of a hand would be no serious drawback in tending poultry, in feeding and tending calves, pigs, or other live stock, and the disabled man might find an outlet for his own energies in these directions.

Several of the smaller branches should, wherever possible, be taken up together, as the small holding can usually be more successfully developed when that is done.

Quite a large number of disabled men might be fully provided for by the village scheme. Even if no more than ten or twelve men were, on the average, absorbed by each selected village, the cumulative effect would be very marked, and in no case would extra provision in the way of schools with their attendant staffs, churches, &c., be required.

The number of men any single village should absorb would depend on its suitability for the purposes of the scheme, but it would be a great mistake to attempt to settle too many men in one village.

In the furtherance of this method of settlement it would be essential to have a list of all villages fulfilling certain minimum requirements, particularly in relation to prevailing climatic conditions, quality and quantity of land available, the marketing of produce at reasonable expense and in good condition. Information should also be tabulated relative to each village fulfilling the minimum requirements, dealing with such points as the various rural occupations and subsidiary industries that could be most successfully developed in that particular village, the buildings that are available, the facilities for altering and equipping existing buildings, and for the erection of new buildings.

The settling of disabled men in small holdings, either on the colony system or on isolated holdings, is another step towards the desired solution of the problem.

The colony method already briefly reviewed in an earlier part of this paper is in some respects on similar lines to those recommended, particularly in the case of ex-service men, by the Departmental Committee appointed to consider settlement or employment of discharged sailors and soldiers on the land.

In putting the colony system into practice in the case of disabled men, one of the best and simplest methods would be for the Government to purchase a number of farms which are suitable both as regards accessibility and quality of land. These farms should be 500 acres or over in extent. If a selected farm was 600 acres in extent, at least 200 acres of the land more remote from the farmhouse and steading should be set aside for the immediate purpose of providing small holdings, to be developed by the disabled men in accordance with nature of disablement, personal preference, previous education and experience, and the support they are able to obtain either in or outside their own family.

While it would be a mistake to have too great a variation in the rural occupations set up at any one centre, it would be well not to restrict these unduly, and the more important should always be established.

The small holdings set up should be fully equipped as regards dwelling-houses, outbuildings, &c., for the branches to be taken up. The holdings should be arranged in such a way that future extension can be easily effected. The special need of the scheme, as far as the disabled men are concerned, is for a single generation; but in the interests of the nation as a whole, when the need so far as the disabled men are concerned is over, 100 or even 200 acres of land, according to the size of the farm, should be available for the extension of the holdings to make these economic propositions, even without the disabled man's pension.

In such a scheme expenditure on buildings would no doubt be heavy, but that should be faced cheerfully. It would be for a good cause, and would only repay in very small part our indebtedness to the disabled men.

Association with a central farm would have very great benefits for the disabled men. The farm would be under the charge of a capable expert, who would exercise a general supervision over all the holdings. It would be cropped on rotation lines best suited to the district and the needs of the small holders.

If a small holder wished the assistance of horse labour in developing his holding, that would be supplied by the farm,

and paid for by the small holder at reasonable rates. If he preferred to devote his whole time to developing the branches of small farming, taking up, for example, dairying, rearing calves, pig-breeding and feeding, poultry-keeping, he could be supplied with such suitable foodstuffs as the farm produced, at a price based on, but just a little above, cost of production. Concentrated foods, seeds, manures, &c., could also be purchased through the farm.

After the first generation the small holdings would be extended, if required, to make them possible economic propositions, and the farm then let as an ordinary farm.

Such a scheme would, of course, ultimately greatly reduce the area available as a farm proper, but anything from 300 to 400 acres of good cropping land utilised on intensive methods will afford ample scope and furnish a sufficient variety of problems to tax the best brains in agriculture.

In addition to what might be accomplished through settling disabled men in villages and small holdings on the colony system, many might be suitably provided for by establishing a number of holdings in isolated positions to be developed pretty much as separate units along the lines that will suit best in each particular district and according to the capabilities of the disabled men. The holdings would be developed on very similar lines to those already indicated, but in addition willow-growing and basket-making might be taken up where feasible, or the cultivation and collection of medicinal herbs or work in a forest nursery, if there is one conveniently situated, or in the forest itself if the man's disablement did not unfit him for it.

The full responsibility for carrying the scheme for training and settlement into effect should rest on the Board of Agriculture, but all existing committees and organisations, such as the Statutory Committee under the War Pensions Act, Local Authorities, County Councils, Agricultural Colleges, &c., should be made as full use of as possible.

No matter what method of settling the men is adopted, the State should, where necessary, provide the capital to purchase the land, also to meet the cost of erecting any buildings and providing other similar equipment.

The disabled men will be in receipt of pensions based on their wage-earning capacity, and should thus be in a position to pay an economic rent for the land and buildings. A few may be sufficiently well off to be able to fully stock their own holding, but many will not be so fortunately placed, and for such further assistance will be required. This may take the form of grants and donations from different sources, or a loan from Government may be necessary. Any loan granted should be at a low rate of interest, with no repayment for at least three years. After that a definite proportion of the loan might be repaid annually. The method of repayment, to which attention has already been drawn, whereby every £5 repaid is reckoned as £10, has much in its favour, and the additional State assistance required to make this possible is a very small thing compared with the men's sacrifice on the nation's behalf.

Even when the men are happily settled, one factor with a very important bearing on their future success will be the measure of co-operation that can be developed. This is particularly important in all methods of settlement. The small man is tremendously handicapped in his buying and selling. That handicap must be removed, and it can only be removed by co-operation amongst the men.

Another equally important factor will be the provision made, apart from preliminary training, for the giving of expert advice and guidance. Many of the men will at first have little more than a fair working knowledge of the branches they decide to take up. They may get along quite well when the road is smooth, but when it becomes steep and precipitous they will often need a guiding and a helping hand. It should be the duty of our Agricultural Colleges to furnish experts to give that helping hand.

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The West of Scotland Agricultural College.

REPORT ON AN EXPERIMENT

ON THE

MANURING OF OATS.

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REPORT ON AN EXPERIMENT ON THE MANURING OF OATS.

Introductory.

THE variation in the yield of the Oat crop per acre from year to year is at times so pronounced that one is apt to give scarcely due consideration to some of the other factors affecting the yield. In these days, however, when the necessity of getting as much food as possible from every acre of land has been brought so vividly to our notice, the other factors affecting the yield of the Oat crop claim special attention—and while manuring is only one of these factors, it is a very important one, and to-day assumes greater importance than ever before.

No doubt the production of Oats might be greatly increased by putting a larger area under the plough, and in this respect there is good reason to believe that the special effort made in recent months will be renewed in another season. Apart, however, from the possibility of increasing the yield by increasing the area under this crop, it is undoubtedly the case that the average yield per acre might be considerably raised by judicious manuring.

The average yield per acre of Oats in Scotland over the last ten years was approximately 38 bushels. Compared with other countries, and taking soil and climate into account, this yield is not unsatisfactory, but nevertheless it is a long way short of the possible yield.

The following table gives the approximate acreage and average yield of the Oat crop in different countries over a five years' period, 1909 to 1913 inclusive. Since the outbreak of war there has in some cases been a very considerable increase in the area under this crop, while in other cases there has been a reduction.

Country.	Approximate Area under Crop. (Acres.)	Yield per Acre. (Bushels).
United Kingdom	4,090,000	43
England and Wales	2,065,000	41 35
Scotland	963,000	38
Ireland	1,062,000	49
Belgium	623,000	56
Netherlands	345,000	48
Switzerland	100,000	47
Germany	10,800,000	44
Denmark	1,032,000	43
Norway	265,000	36
Japan	112,000	36
Sweden	1,970,000	34
France	9,700,000	30
Austria	4,600,000	29
Canada	10,000,000	29
United States	37,000,000	25
Italy	1,250,000	24
Roumania	1,110,000	21
Russia (in Europe)	42,000,000	18
Spain	1,285,000	18

Numerous experiments on the manuring of Oats have now been conducted, and the requirements of this crop in the way of manurial ingredients are already well known. Nevertheless, when we consider the average yield per acre for Scotland, and at the same time think of the yields per acre actually obtained on many farms, that from point of view of soil and climate could at best be classed only as second rate, we cannot but conclude that manuring the Oat crop is not nearly so widely practised as it might with advantage be.

In order that the Oat crop may benefit to the fullest extent from the application of manure, it is essential that the soil contain a fair balance of lime, because of the varied and all-important part played by that substance. In addition to keeping up a supply of lime we must provide in sufficient amount suitable compounds of Nitrogen, Phosphate, and Potash.

The actual part played by each of these ingredients has now been pretty well established. We know, for example, that the Phosphate plays a very important part throughout the whole period of growth from start to finish. It enables the young Oat plant to develop root more quickly and get over what is known as the "sitting" stage. It has also a marked effect in promoting tillering, so that on land well stored with Phosphates, if a tillering variety of Oat is sown, a smaller quantity of seed will suffice. Being more intimately connected with seed formation than with production of leaf and stem, the Phosphate, provided the other ingredients are available in sufficient amount, tends to make the crop much more fruitful. It has a marked effect in increasing the number of grains on each head, and without this ingredient the same increase never takes place. In addition, the Phosphate tends to hasten the ripening of the crop, which effect, though occasionally a slight disadvantage in a dry season, is undoubtedly of very great importance in a late season or in late districts.

The part played by Potash is also well known, and this is always a specially important ingredient for crops which produce much starch or sugar. It plays a part in connection with Carbon Assimilation which is the starting-point for the formation of starch and sugar in the plant, and because of this it tends to give plump well-filled grain.

The Phosphate undoubtedly has an effect in increasing the number of grains, but the Potash is in great measure responsible for the full development of these.

Further, it tends to strengthen the straw of the Oat crop, with the result that the crop does not lodge so readily. This effect is very important where a big yield per acre is aimed at. It has also an effect on the health of the plant, the crop being less liable to fungoid and certain other diseases. In a dry season particularly it rather tends to prolong the growth, and to some extent counteracts the effect of the Phosphate.

In some respects Nitrogen plays the most important part of all the manurial ingredients, for, if deficient, growth is always poor and stunted. It has a very marked effect on rate of growth, and has much to do with the production of leaf and stem. Too liberal a use of Nitrogen makes the crop more liable to lodge, as it is drawn up too quickly. It also rather delays ripening. When applied in moderate quantity, and along with Phosphate and Potash, the result is the very reverse, for not only does the crop ripen earlier but it also stands up much better.

Many farmers hesitate to manure their Oats because they are afraid that the application of manure will greatly encourage

lodging. If the quantity of Nitrogen is kept in moderation they need have no fears on that score, as a well-balanced manure strengthens the crop and enables it to stand up much better. A worthy and very wide awake farmer in the south of Scotland once assured the writer that until he commenced to manure his "Red land" Oats they were almost always down at harvest time, but he had found from experience that it was because they had not strength to stand up.

This effect of manuring was very noticeable in the results obtained in 1915 and 1916 on some of the Demonstration Areas under the West of Scotland Agricultural College. At Lockerbie, for example, six acres were fully manured with Superphosphate, Potash, and a little Sulphate of Ammonia, and $1\frac{1}{2}$ acres were unmanured. The yield was considerably higher on the manured portion, yet in spite of that this part of the field stood up very much better than the unmanured part.

At Biggar Demonstration Area last season a very similar result was obtained, although Salt was used in place of Potash. The crop was practically all standing, and yet the yield was nearly 50 per cent above the average yield for Scotland.

Manuring will undoubtedly encourage lodging of the Oat crop if too much Nitrogen is applied, but if a fair dressing of Phosphate and Potash—or some substance, such as Salt, to liberate the soil Potash when Potash manures are not available —be given, and the Nitrogen be used in moderate amount, or omitted altogether under exceptional conditions, as when rich old pasture land or grass land full of clover is broken up, there is no great risk of trouble on that score.

In the following pages a short account is given of some experiments commenced by the West of Scotland Agricultural College in 1912. The experiments were continued in 1913 and 1914, but had to be discontinued from 1915 on account of the war.

The investigation is by no means complete, but the results already obtained are of considerable value, in that they show to what extent the yield of the Oat crop is likely to be increased by the judicious application of artificial manures.

The experiments were carried out on selected farms pretty widely scattered and fairly representative of the area served by the College. A wide variety of soils were represented, but on every farm special care was taken to select for the experiment what seemed to be a uniform area.

The plots on which the experiments were conducted were each one-tenth of an acre in extent. A uniform quantity of seed was applied to each plot, and the plots were treated exactly alike in all respects save that of manurial treatment.

The scheme of manuring was as follows[1]:—

Plot.	Manure applied per acre.	
I.	Unmanured.	
II.	2 cwt. Superphosphate, 30%	Harrowed in at time of seeding.
III.	2 cwt. Superphosphate 2 cwt. Kainit	Harrowed in at time of seeding.
IV.	2 cwt. Superphosphate 2 cwt. Kainit	Harrowed in at time of seeding.
	1 cwt. Nitrate of Soda	Applied as a top-dressing when crop has brairded.
V.	2 cwt. Superphosphate 2 cwt. Kainit	Harrowed in at time of seeding.
	134 lb. Nitrate of Lime	Applied as a top-dressing when crop has brairded.
VI.	2 cwt. Superphosphate 2 cwt. Kainit 87 lb. Sulphate of Ammonia	Harrowed in at time of seeding.
VII.	2 cwt. Superphosphate 2 cwt. Kainit 97 lb. Nitrolim	Harrowed in at time of seeding.

The Nitrate of Lime, Sulphate of Ammonia, and Nitrolim supplied exactly the same amount of Nitrogen as was contained in 1 cwt. of Nitrate of Soda.

As will be seen from the scheme of manuring, all the manures were harrowed in at the time of seeding excepting the Nitrate of Soda and the Nitrate of Lime, which, being rather quicker in their action than the other nitrogenous manures, were top-dressed just after the Oats had brairded.

The experiment was designed for the purpose of ascertaining what increase in yield might reasonably be expected from the application of a fair dressing of artificials under ordinary conditions, and also with a view to noting the relative effects of the four nitrogenous manures—Nitrate of Soda, Nitrate of Lime, Sulphate of Ammonia, and Nitrolim—when applied at equivalent rates of Nitrogen, and when used along with Superphosphate and Kainit.

In each of the years in which the experiments were conducted, in spite of very careful working, a number of results had to be discarded owing to varying circumstances over many of which the experimenters had no control, but a total of 17 complete and very reliable returns were obtained: 7 in 1912, 5 in 1913, and 5 in 1914.

The farms from which complete and reliable returns were

[1] In the carrying out of the experiment in the field the order of the plots was slightly different to what is indicated here. The present arrangement was adopted for sake of simplicity, as it shows more clearly the increase due to manuring.

obtained, the nature of the soil at each centre, and the previous crops were as follows:—

Season.	Centre.	Nature of Soil.	Previous Crop.
1912.	Blairgorts, Stirlingshire.	Sandy loam.	Turnips.
,,	Davington, Langholm, Dumfriesshire.	Light loam.	Pasture.
,,	Garden, Port of Menteith, Stirlingshire.	Carse land.	Turnips.
,,	Harelawhill, Canonbie, Dumfriesshire.	Stiff loam.	Turnips.
,,	Henshilwood, Carnwath, Lanarkshire.	Loam.	Turnips.
,,	High Borland, Eaglesham, Renfrewshire.	Light gravelly soil.	Potatoes.
,,	Newfield, Dalry, Kirkcudbright.	Medium loam.	Pasture.
1913.	Fingart, Dunlop, Ayrshire.	Peat over clay.	Oats.
,,	Kells of Southwick, Kirkcudbright.	Sharp soil.	Turnips.
,,	Raithhill, Coylton, Ayrshire.	Poor till.	Oats.
,,	The Lodge, Slamannan.	Medium loam.	Pasture.
,,	Whole Flats, Grangemouth, Stirlingshire.	Carse land.	Pasture.
1914.	Avonbridge, Kippen, Stirlingshire.	Medium loam.	Oats.
,,	Ducherain, Lochgilphead, Argyll.	Medium loam.	Pasture.
,,	East Flanders, Stirlingshire.	Stiff carseland.	Oats.
,,	Headswood, Denny, Stirlingshire.	Light loam.	Pasture.
,,	Raeburnfoot, Gretna, Dumfriesshire.	Red loam.	Pasture.

For Summary of Results see page 243.

Notes on the Results.

The larger yield of straw per acre in 1912, as compared with 1913 and 1914, was no doubt in great measure due to the fact that in 1912 the month of April was one of the best on record. It was on the whole the finest month of the year. The Oat crop was put in under ideal conditions, and made specially good progress in that month. May was on the whole also a favourable month, but the rainfall in June was considerably above the normal. July was a seasonable month, but August was cold and changeable and ripening made but little progress, the result at harvest being a moderate yield of grain and a large yield of straw.

SUMMARY OF RESULTS OBTAINED IN THE DIFFERENT SEASONS.

Season 1912.

Plot.	Average yield of grain.	Increase over unmanured plot.	Average yield of straw.	Increase over unmanured plot.	Manure applied.
	Bushels.	Bushels.	Cwt.	Cwt.	
I.	39	—	35¼	—	None.
II.	41¼	2¼	37½	2¼	Superphosphate.
III.	43¾	4¾	39¼	4	Superphosphate and Kainit.
IV.	50	11	49	13¾	Superphosphate, Kainit, and Nitrate of Soda.
V.	52	13	49¼	14	Superphosphate, Kainit, and Nitrate of Lime.
VI.	50¾	11¾	46¼	11	Superphosphate, Kainit, and Sulphate of Ammonia.
VII.	50½	11½	44	8¾	Superphosphate, Kainit, and Nitrolim.

Season 1913.

I.	37½	—	25	—	None.
II.	40½	3	26¼	1¼	Superphosphate.
III.	42¾	5¼	28¾	3¾	Superphosphate and Kainit.
IV.	49	11½	30¼	5¼	Superphosphate, Kainit, and Nitrate of Soda.
V.	51	13½	33½	8½	Superphosphate, Kainit, and Nitrate of Lime.
VI.	52½	15	36¾	11¾	Superphosphate, Kainit, and Sulphate of Ammonia.
VII.	50	12½	36½	11½	Superphosphate, Kainit, and Nitrolim.

Season 1914.

I.	48	—	22	—	None.
II.	49¼	1¼	21	(−1)	Superphosphate.
III.	53¼	5¼	24	2	Superphosphate and Kainit.
IV.	62½	14½	30	8	Superphosphate, Kainit, and Nitrate of Soda.
V.	61¼	13¼	27½	5½	Superphosphate, Kainit, and Nitrate of Lime.
VI.	61½	13½	29	7	Superphosphate, Kainit, and Sulphate of Ammonia.
VII.	55½	7½	26¼	4¼	Superphosphate, Kainit, and Nitrolim.

The relatively large yield of grain and the smaller yield of straw in 1914 is again due to the season. The month of June, instead of being wet as in 1912, was exceptionally dry, being one of the driest on record, and the latter part of the month was very warm. In July the rainfall was again below the normal and the temperature above normal. The production of straw suffered to some extent on that account, but the crop ripened under favourable conditions. The harvest was an early one, and the yield of grain per acre considerably above the normal.

Although seasonal variation is very important, the summary of results for the years 1912, 1913, and 1914 shows clearly that the increases due to the application of manures were very similar in each of these years, especially as regards the production of grain.

The following table gives the average yield over the three seasons 1912, 1913, and 1914 from the seventeen experiments:—

Plot.	Average yield of grain.	Increase over unmanured plot.	Average yield of straw.	Increase over unmanured plot.	Manure applied.
	Bushels.	Bushels.	Cwt.	Cwt.	
I.	41¼	—	28¼	—	None.
II.	43½	2¼	29½	1¼	Superphosphate.
III.	46¼	5	31¾	3½	Superphosphate and Kainit.
IV.	53½	12¼	38	9¾	Superphosphate, Kainit, and Nitrate of Soda.
V.	54½	13¼	38¼	10	Superphosphate, Kainit, and Nitrate of Lime.
VI.	54½	13¼	38½	10¼	Superphosphate, Kainit, and Sulphate of Ammonia.
VII.	51¾	10½	36½	8¼	Superphosphate, Kainit, and Nitrolim.

In view of the above, on the average of seasons and under normal conditions, one may reasonably expect an application of 2 cwt. of Superphosphate (30 per cent) per acre to increase the yield of the Oat crop over the average production of similar unmanured areas by about 2¼ bushels grain and 1¼ cwt. of straw.

An application of 2 cwt. Superphosphate and 2 cwt. Kainit under similar conditions will be likely to increase the yield to the extent of 5 bushels of grain and 3½ cwt. of straw; while a complete dressing, including 2 cwt. Superphosphate, 2 cwt. Kainit, and a nitrogenous manure equivalent to 1 cwt. Nitrate of Soda may be expected to increase the yield by as much as 12 bushels of grain and about 10 cwt. of straw per acre.

The monetary value of the increase in yield on the differently manured plots, at the pre-war prices of 20s. per quarter of Oats (320 lb.) and 30s. per ton of straw, and the return per acre, after deducting the full cost of the manure applied, irrespective of residual value, is as follows:—

Plot.	Increase from Manuring.		Value of increase.	Cost of Manure.	Return per acre.
	Bushels grain.	Cwt. straw.			
			s. *d*	*s.* *d.*	*s.* *d.*
II. . . .	2¼	1¼	7 6	6 3	1 3
III. . . .	5	3½	17 9	11 9	6 0
IV. . . .	12¼	9¾	45 3	21 9	23 6
V. . . .	13¼	10	48 1½	22 6	25 7¼
VI. . . .	13¼	10¼	48 6	21 1	27 5
VII. . . .	10½	8¼	38 7½	20 0	18 7½

These figures show that after deducting the full cost of the artificials applied there is in every case a balance in favour of manuring, but that by far the best return is got from the fully manured plots. With the exception of the Nitrolim plot there is comparatively little difference in the return from the fully manured plots, but, on the whole, Sulphate of Ammonia along with Superphosphate and Kainit has given the best return.

The benefit from using a well-balanced manure would in all probability have been even more pronounced if a good grain-producing variety of Oat like Victory or Record had been used for all the experiments. In several cases, Sandy, Friesland, Longhoughton, Potato, and similar varieties were sown, but while these varieties have many admirable features, they cannot respond to manuring in quite the same way as some of the newer grain-producing varieties. In order to get the full benefit from liberal manuring a good prolific variety of Oat should be selected.

Effect of the Manuring on time of Ripening.—There was quite a marked difference in the time of ripening of some of the plots. As a rule, the unmanured plot was the last to ripen, and some of the experimenters reported that it was considerably behind the other plots in that respect.

Of the fully manured plots the Nitrolim ones were the first to ripen, being generally a few days ahead of the Sulphate of Ammonia plots, which came second. The Nitrate of Soda and Nitrate of Lime plots were a little later in ripening, but they were always earlier than the unmanured plots.

The fact that the Nitrolim has a marked effect in hastening ripening helps to explain the rather poorer yield from this manure in season 1914, as the harvest in that year was an

early one. The Nitrolim is likely to give a rather better return in seasons that are not too early, or in some of the later districts, and careful analysis of the results supports this view. For example, at Davington, Langholm, in a late high district (elevation about 750 feet), fully the best return both in grain and straw was obtained from this manure. Not only so, but the crop on this plot was the first to ripen.

At Henshilwood, Carnwath, in another late high district (elevation 800 feet), this manure again gave the best return, and the experimenter reported that it was the first plot to ripen.

Effect on Lodging.—For the most part the plots kept up fairly well, and there were no complaints about the manuring causing the crop to lodge. In one or two cases the plots did go down, and there is reason to believe that when there is a risk of the crop lodging, if any nitrogenous manure is applied, sulphate of Ammonia or Nitrolim should be used in preference to Nitrate of Soda or Nitrate of Lime, as in the opinion of several of the experimenters the two latter manures gave rather softer straw, which tended to go down more easily.

The results obtained in these experiments emphasise the importance of applying a well-balanced manure to the Oat crop, as the average yield on the fully manured plots is about 30 per cent above that obtained on the unmanured plots, and fully 33 per cent in advance of the average yield for Scotland. Our present average yield of Oats is still far short of the possible, and our aim should be to get as near maximum profitable production as we can.

The yield of Oats per acre in Belgium prior to the war was 56 bushels per acre, while the yield for Britain and Ireland was only about 43 bushels.

This difference in yield is not to be wondered at when we consider that the intensity of fertiliser consumption per acre of agricultural land in Belgium was fully three times that of the United Kingdom.

In Holland and in Germany the rate of application is also very much in advance of ours, and is justified by the yields obtained.

In view of the results obtained in these experiments, one may reasonably conclude that a more general and more liberal use of artificial manure would effect a considerable increase in our present average yield of Oats.

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ON

SUGAR BEET TRIALS, 1917;

CALF FEEDING EXPERIMENTS;

ISLE OF WIGHT BEE DISEASE;

DEMONSTRATION POULTRY CROFTS;

SMALL-HOLDER'S CHEESE; SKIM-MILK CHEESE; COTTAGE CHEESE;

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FIFTEENTH ANNUAL REPORT.

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GLASGOW, 1918.

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NOTE OF ACKNOWLEDGMENT.

The Governors of the College have pleasure in expressing their indebtedness to farmers and others who gave facilities for the carrying out of certain of the experiments dealt with in this Report, and who incurred much trouble, and not a little expense, in their careful supervision and execution.

Bulletin No. 83.

The West of Scotland Agricultural College.

REPORT

ON

SUGAR BEET TRIALS, 1917.

BY

Professor R. A. BERRY.

Glasgow:
Printed by Robert Anderson, 142 West Nile Street.

1918.

REPORT ON SUGAR BEET TRIALS, 1917.

BY

Professor R. A. BERRY.

Sugar Beet was grown at a number of centres in Ayrshire and Wigtonshire in 1917, the arrangements being made by Mr. James E. Shaw, High Greenan, Ayr. Samples for analysis were obtained from each centre.

The following is a list of the centres :—

Field Plots.

James Bone, Robstone, Girvan.

Fred. I. Cochrane, Craigcaffie, Stranraer.

John Douglas, High Balyett, Stranraer.

Stair M'Harrie, Balker Home Farm, Stranraer.

Archibald Jack, Bridge of Aird, Stranraer.

W. C. Wilson, Holmhead, Daljarrock.

Garden Plots.

James E. Shaw, High Greenan, Ayr.

James E. Shaw, M'Pherson's Garden, Ayr.

James MacKenzie, Gardener, Cassillis House, Dalrymple.

J. Findlay, Gardener, Blair Gardens, Dalry, Ayrshire.

The size of the field plots varied from one-half acre to over one acre, while the garden plots consisted of several rows.

The method of cultivation of the crop at each centre has been supplied by the different experimenters, and is summarised in Table I.

Table I.—Field Plots.

Name of Farm.	Type of Soil and Previous Crop.	Manures per Acre.	Seed.			Width of Drills.	Average Space between Roots.	Roots Bolted.	Proportion of Root to Tops.
			Weight per Acre. Lbs.	Date of Sowing.	Date of Singling.				
						Inches.	Inches.	Per cent.	Per cent.
Robstone, ...	Good Loam. Mangels.	Dung, 15 tons, ... Potato Manure, 8 cwts. Sulphate of Ammonia, 1½ cwts.	15	May 5	June 25	26	6	16	50
Craigcaffie, ...	Light gravelly. Oats.	Meat and Bone Manure, 9 cwts., ... Superphosphate, 6 cwts.	13	,, 10	July 15	28	10	30	76
High Balyett, ...	Light Loam. Oats.	Dung, 15 tons, ... Bone Meal, 10 cwts. Sulphate of Ammonia, 2 cwts.	14	,, 5	,, 3	26	10	30	77
Balker Home Farm	Light gravelly. Oats.	Dung, 15 tons, ... Basic Slag, 10 cwts. Bone Meal, 4 cwts. Sulphate of Ammonia, 1 cwt.	12	,, 5	,, 16	28	6	20	80
Bridge of Aird, ...	Deep Loam. Oats.	Dung, 24 loads, ... Mangel Manure, 12 cwts.	14	,, 15	,, 7	27	9	5	—
Holmhead, ...	Light. Cabbage.	Basic Slag, 10 cwts., ... Chemical Guano, 8 cwts. Sulphate of Ammonia, 1½ cwts.	12	Apr. 25	June 12	24	8	3	75

The dung was applied to the land in the autumn and ploughed in. The artificial manures used and the weight of seed sown varied at the different centres. The seed was supplied by Messrs. Carter & Co., and the same variety, "Klein-Wanzleben," was sown at each centre. The seed could not be obtained till late in the month of April, and accordingly arrangements could not be made for the proper preparation of the land where it was sown.

The writer, in company with Mr. Shaw, visited each of the centres on 21st of September last. The general impression then gained from the appearance of the crop was a very favourable one. The plants were in a healthy growing condition with a good development of leaves. It was noticeable that rather a large proportion of plants had run to seed or "bolted." The proportion is given in Table I. Bolted plants contain a low percentage of sugar, and are practically useless for sugar production. The cause of the "bolting" in the present instance can only be surmised, but since the seed supplied was the same in each case and at two of the centres the proportion of plants bolted was low, probably a check caused by frost received in the early stages of growth accounts for it.

At each of the centres the shoulder of many of the roots was exposed. Under proper cultivation the roots should be completely covered with soil. Exposure diminishes the amount and purity of the sugar in the root. The roots as a whole were larger than the average size of root grown in England and on the Continent, and at most of the centres they included a fair proportion of badly-shaped bulbs showing secondary roots or fangs.

Sampling and Analysis.—Twenty-five representative roots from each centre were taken as a sample. The weight of each individual root was recorded, and the average weight is given in Table II. (See also Table V., page 10.) For the analysis each root was cut in half longitudinally, one half then quartered, one quarter being used for the extraction of the juice and the other for the estimation of the dry matter. The juice was used for the different determinations. The analyses were made in the Chemistry Department of the College, and the result is given in Table II.

Table II.—Field Plots.

Name of Farm.	Date of Sampling.	Roots.			Juice.			Yield per Acre.	
		Average Weight of Washed Root Sampled Grams.	Dry Matter Per Cent.	Sugar Per Cent.	Specific Gravity.	Sugar Per Cent.	Purity of Sugar Per Cent.	Roots Unwashed. Tons.	Sugar. Tons.
Robstone, ...	Nov. 5	720	23·58	16·00	1·085	16·83	86·5	15·3	2·44
Craigcaffie, ...	,, 2	627	23·91	16·64	1·086	17·52	86·7	5·5	0·91
High Balyett, ...	,, 5	751	23·01	15·81	1·084	16·66	89·7	8·25	1·30
Balker Home Farm, ...	,, 6	762	22·53	15·89	1·081	16·74	89·8	10·0	1·59
Bridge of Aird, ...	,, 14	850	22·12	14·67	1·080	15·44	84·3	5·0	0·73
Holmhead, ...	,, 5	822	22·01	15 29	1·081	16·11	87·1	12·0	1·83
Average, ...	...	755	22·86	15·71	1·083	16·55	87·3	9·3	1·46

Garden Plots.

Name of Garden.	Date of Sowing.	Date of Sampling.	Roots.			Juice.		
			Average Weight of Washed Root Sampled Grams.	Dry Matter Per Cent.	Sugar Per Cent.	Specific Gravity.	Sugar Per Cent.	Purity of Sugar Per Cent.
High Greenan, ...	May 29	Nov. 12	631	22·93	16·58	1·083	17·45	89·6
M'Pherson's, ...	,, 7	,, 12	1,009	21·86	15·28	1·079	16·09	87·4
Blair Garden, ...	June 1	Oct. 31	686	20·1	12·10	1·069	12·72	77·1
Cassillis House, ...	,, 1	,, 15	332	19·07	11·17	1·043	11·87	78·2

The sugar content of the roots in the field trials is satisfactory, and the purity of the sugar in the juice is also satisfactory. Owing to the unusual weather conditions, growth continued late into the autumn. The samples were not taken until the month of November at which date the plants were still growing. There had not been sufficient frost to cause injury, and generally the crop was not lifted until some days after the sampling. The sugar content, and also the quotient of purity of the sugar, are highest in the ripe plant. A good example of this is provided in the samples from the garden plots at Cassillis House and Blair House. In each case the sample was taken before the plants were evidently ripe, with the result that their sugar content suffered. (See Table II.)

For the purpose of comparison data showing the averages of crop yields in foreign countries are given in Table III.* The average figures taken from Table II. of this report are also included.

TABLE III.

COUNTRY.	BEETROOT.					
	Sugar Percentage in Root.		Yield per Acre in Tons.			
			Roots.		Sugar.	
	1911-12.	1912-13.	1911-12.	1912-13.	1911-12.	1912-13.
Germany, - -	16·8	16·5	7·04	11·97	1·18	1·98
Austria-Hungary,	14·7	15·2	7·67	11·19	1·13	1·70
France, - -	12·6	14·6	7·15	11·54	0·90	1·69
Belgium, - -	15·3	15·2	10·45	11·88	1·60	1·81
Holland, - -	15·7	15·9	12·45	11·54	1·95	1·83
Italy, - -	11·3	12·7	11·34	12·71	1·28	1·61
Russia, - -	15·8	13·4	6·63	5·38	1·05	0·72
	1917		1917		1917	
Scotland, - -	15·71	—	9·3	—	1·46	—

* *Journ. Bd. of Agriculture*, Vol. XXI., No. II, p. 999.

The weather conditions as recorded at Kilmarnock are indicated in Table IV. :—

TABLE IV.

	RAINFALL IN INCHES.		HOURS OF BRIGHT SUNSHINE.	
	Average for 16 years.	1917.	Average.	1917.
May, - - -	2·41	2·62	159	142
June, - - -	2·17	3·01	176	233
July, - - -	2·96	2·39	169	203
August, - -	4·21	3·04	137	120
September, - -	2·71	2·58	116	89
October, - -	3·57	7·81	75	72
November, -	3·52	8·79	43	26

The rainfall for the months of October and November of this year was the highest for these two months since records have been kept at Kilmarnock.

In ordinary years spells of frosty weather often occur in the months of October and November, and, as frost injures the plant, the crop would in all probability require to be lifted earlier than in the present season. If the beet is well protected with soil the probability of harm from frost would be lessened. The weather, particularly in September, is the important factor in controlling the process of ripening. On the Continent the crops are usually mature, and are lifted in the last week of September or early in October. Owing to a more open climate with a higher rainfall and less sunshine the ripening of the crop will be later in this country, and will vary each year according to the season, type of soil and locality.

The figures showing the yield of roots per acre were supplied by each of the experimenters. Deductions for the soil adhering

to the roots and for the bolted roots must be made from the yields of the roots and the sugar per acre. Soil sometimes amounts to nearly 20 per cent. of the weight of the unwashed roots, according to the conditions of the soil and of the weather at the time of lifting, and also according to the shapeliness of the root.

The following is a complete analysis of the beet grown at Craigcaffie, Stranraer :—

Water,	76·09	per cent.
Carbohydrates crude,	20·54	,,
Protein* ,,	1·59	,,
Fibre ,,	1·20	,,
Ether extract ,,	0·02	,,
Ash† ,,	0·56	,,
Total,	100·00	,,

* Including ·76 per cent. of pure Protein.

† Including ·12 per cent. of Potash (K_2O), ·134 per cent. of Phosphoric acid (P_2O_5).

The maximum, minimum, and the average weight of individual roots, and also the percentage of Ash in the beet juice at each of the centres, are given in the following Table V. :—

TABLE V.

	Weight of individual roots, grams.			Ash in Juice.
	Max.	Min.	Average.	Per-centage.
FIELD PLOTS—				
Robstone, - -	1,333	387	720	0·69
Craigcaffie, - -	922	388	627	0·51
High Balyett, -	1,300	379	751	0·55
Balker Home Farm,	1,177	404	762	0·58
Bridge of Aird, -	1,281	424	850	0·77
Holmhead, - -	1,172	284	822	0·82
Average, -	1,197	378	755	0·65
GARDEN PLOTS—				
High Greenan, -	1,107	313	631	0·70
M'Pherson's, -	1,621	427	1,009	0·82
Blair, - - -	1,055	717	886	1·08
Cassillis, - -	572	171	332	1·04
Average, -	1,044	407	714	0·91

The writer grew three varieties of sugar beet, namely, "Vilmorin," "Aderstedt," and "Klein-Wanzleben," at Holmes Farm in 1905, with satisfactory results. (See College Bulletin No. 40.)

SUMMARY AND RECOMMENDATIONS.

The trials in 1917 show that sugar beet, under ordinary field conditions, can be grown satisfactorily in Ayrshire, so far as the percentage of sugar in the root and the purity of sugar in the juice are concerned. The average percentage of sugar in the root was 15·7, and the average purity of the sugar in the juice 87·3 per cent. More trials are, however, necessary to establish the crop producing power of the beet, and the tendency or otherwise of the beet to "bolt" under the soil and climatic conditions prevailing in the West of Scotland.

Further field trials in 1918 should be carried out on different types of soil suitable for the cultivation of beet. Sugar beet, under suitable climatic conditions, will grow on most types of soil, with the exception of heavy clays and peat, provided the soil is deep and easy working and with good aeration. For the purpose of comparison, the method of cultivation, weight of seed sown, distance between drills, and space between roots should be as uniform as possible at each of the centres.

The plots should not be smaller than one-half acre.

Liberal manuring with phosphatic and potassic manures is essential, but too large a dressing of nitrogenous manures unnecessarily delays the ripening of the crop, which is a disadvantage in this climate.

An application of about 15 tons of dung per acre to the land, either in autumn or spring, is advisable.

Several of the well-known varieties of sugar beet should be tested.

Early sowing to encourage early maturity is advisable, but the injurious effect of late spring frosts must, as far as possible, be avoided.

Owing to the climatic conditions which prevail in the West of Scotland, the crop would not in average years be ripe and ready to lift until about the month of November.

Sugar beet and mangel require similar conditions of soil and climate for their cultivation.

Vol. XXI., No. II., *The Journal of the Board of Agriculture*, contains a valuable paper on the cultivation of

sugar beet. It is there recommended that the drills should be from 16 to 18 inches apart, and the space between the roots from 8 to 10 inches.

The manures there recommended are—

Dung, ...	8 to 16 tons per acre.
Superphosphate from ...	$2\frac{1}{2}$ to $4\frac{1}{2}$ cwts. per acre.
Nitrate of Soda, ...	$1\frac{1}{2}$ to 2 „ „
Sulphate of Potash, ...	$1\frac{1}{2}$ „ „

Heavier dressings of phosphatic manures than the above might be used with advantage in the West of Scotland. The condition of the soil, previous cropping, and manuring of the land would require to be taken into account in any scheme of manuring.

17th December, 1917.

Bulletin No. 84.

West of Scotland Agricultural College.

REPORT

ON

CALF FEEDING EXPERIMENTS

CONDUCTED AT

THE COLLEGE FARM, KILMARNOCK,

IN

1916 and 1917,

BY

WILLIAM G. R. PATERSON, B.Sc., N.D.A. Hons.,
Principal and Professor of Agriculture.

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1918.

REPORT ON CALF FEEDING EXPERIMENTS CONDUCTED AT THE COLLEGE FARM, KILMARNOCK, in 1916 and 1917.

PRELIMINARY NOTE.

The experiments dealt with in this report were designed and carried out with a view to gaining further information as to the best and most economical methods of rearing calves, particularly in cheese-making districts, where plenty of whey would be available

It is expedient, in the national interest, that as many calves as possible be reared at the present time, but it is equally important that only the minimum amount of whole milk required be utilised for that purpose.

Apart altogether from the necessity for reserving as much whole milk as possible for direct human consumption or for the manufacture of cheese, experiments conducted by the College during seasons 1914 and 1915, and reported on in Bulletin 68, had shown that, in the case of ordinary commercial animals, the cost of rearing calves on whole milk was prohibitive. These experiments also demonstrated that separated milk and crushed oats, or separated milk and maize meal, formed suitable, economical, and very reliable rations for calves, provided they got whole milk for the first four weeks and that the change of ration was gradually effected. In fact, these rations gave live weight increases almost equal to those obtained from feeding solely on whole milk.

Method of Conducting Experiments.

The experiments now under consideration were carried out during seasons 1916 and 1917, and in both years sixteen Ayrshire calves were selected for the investigation. A number of these were home bred, but several had to be purchased to provide the required number. The calves were divided into four groups with four animals in each, and the groups were arranged as uniformly as possible.

All the calves were fed exactly alike for the first three weeks of their lives, their ration during that time consisting solely of whole milk. The allowance at first was small, but it was gradually increased, and the total consumed in the first three weeks was 21 gallons, including colostrum, being equivalent to 1 gallon per calf per day for that period.

At the end of three weeks they were gradually put on to the experimental rations to be tested. The transition period extended over three weeks, so that in every case the calves were six weeks old before the whole milk was entirely withdrawn.

The rations tested were as follows :—

Season 1916.

Lot 1.—Separated milk and crushed oats.
Lot 2.—Whey, oat meal, and fish meal.
Lot 3.—Whey and palm nut.
Lot 4.—Water and palm nut meal.

Season 1917.

Lot 1.—Separated milk and crushed oats.
Lot 2.—Whey, oat meal, and fish meal.
Lot 3.—Whey and palm nut meal.
Lot 4.—Whey, fine thirds, and fish meal.

The reason for the slight change in 1917 was because the water and palm nut meal proved a very unsatisfactory ration, and it was deemed unadvisable to continue with that ration in 1917 ; accordingly, a ration consisting of whey, fine thirds, and fish meal was tried instead.

In both years the experiment lasted for a period of 12 weeks from the whole milk period, so that the calves were 15 weeks old when the investigation was concluded.

Notes on the Results.

In the following pages a short account is given of the method of feeding the different rations, the average weekly increase made by the calves in the different groups, also the cost of the different rations per week and per lb. live weight increase.

In arriving at these costs the following are the prices on which the figures are based :—

	Season 1916.	Season 1917.
Whole Milk, ...	10d. per gallon,	1s. 1d. per gallon.
Separated Milk, ...	3d. ,,	5d. ,,
Whey, ...	1d. ,,	1½d. ,,
Crushed Oats, ...	4s. per bushel,	6s. per bushel.
Oat Meal, ...	48s. per load (280 lbs.),	72s. per load (280 lbs.)
Palm Nut Meal, ...	£9 10s. per ton,	£17 per ton.
Fish Meal, ...	£12 ,,	£16 ,,
Fine Thirds, ...	—	£16 ,,
Linseed Cake, ...	£12 10s. ,,	£22 ,,

There was a very considerable rise in the prices of practically all feeding-stuffs in 1917 as compared with 1916, and while it would have served the purpose quite well to apply even pre-war rates, it was deemed best, in the circumstances, to take the various foods used, when they had a market value,

at the current prices prevailing in both years at the time the experiment commenced. Whey, however, scarcely falls into line with the other foods in that respect, but the allowance per gallon in both years is reasonable.

Lot 1.—*Ration: Separated Milk and Crushed Oats, fed dry.*

This ration was really looked upon as the control ration. It is a much more economical ration than whole milk, and it is also a reliable one, as in all previous trials it had given satisfactory results. Its one and only drawback under normal conditions lies in the fact that it takes some time to accustom the calves to the crushed oats, but ultimately they eat them greedily.

During the transition period whole milk was gradually withdrawn and separated milk and crushed oats substituted in its place. A small quantity of crushed oats was put into each of the pails just before the calves had entirely finished their milk, and in their eagerness to get the last drop of milk they sucked up some of the oats and thereby gradually acquired a taste for them. The quantity of oats fed was steadily increased, and at the conclusion of the experiment the calves were getting fully 1 lb. per head per day—the amount consumed during the period from the time the whole milk was entirely withdrawn being equivalent to an average of ¾ lb. per animal per day.

The quantity of separated milk consumed from the end of the transition period onwards was equivalent to an allowance of 1½ gallons per calf per day over the whole of that period.

Hay was introduced into the ration when the calves were five weeks old, and this was fed *ad lib.* till they were put to the grass.

Linseed cake was also introduced into the ration when the calves were eight weeks old, a very small quantity being fed to begin with, but this was gradually increased, and the quantity consumed during the remainder of the experimental period was equivalent on the average to an allowance of ¾ lb. daily.

The progress made by the calves in this group was entirely satisfactory, though not so good as that obtained in previous years from a rather more liberal ration (of the same nature) and with a better class of calves.

The average weekly increases in live weight made by the calves in Lot 1 in both seasons were as follows :—

Season 1916—Average weekly increase in live weight, 8·75 lbs.
,, 1917— ,, ,, ,, 8·60 lbs.
Average over both seasons, 8·67 lbs.

Applying the prices already given, the average cost of the ration per week for the twelve weeks and the cost per lb. live weight increase is as follows :—

	1916.	1917.
Average weekly cost of ration, ...	3/8	5/10
Cost per lb. live weight increase, ...	5·04d.	8·31d.

Lot 2.—Ration: Whey, Oat Meal, and Fish Meal.

The oat meal and fish meal were fed in the proportion of two-thirds oat meal and one-third fish meal (by weight). The mixed meals were made into a kind of porridge with boiling water, and this was fed along with the whey.

A start was made to introduce whey with a little oat and fish meal porridge into the ration when the calves were three weeks old, and by the end of the sixth week the whole milk was entirely withdrawn. At that time each calf was receiving 1 gallon of whey and ½ lb. of the mixed meals made into porridge. The quantity was gradually increased, the amount consumed over the remainder of the experimental period being equivalent to a daily allowance of 1½ gallons of whey and 1 lb. of meal.

The calves took quite kindly to this ration from the very beginning, no difficulty being experienced in getting them to take it. As in the case of Lot 1, hay was fed from the time the calves were 5 weeks old, and linseed cake introduced into the ration three weeks later.

The four calves in this lot made very satisfactory progress in both seasons. They were perfectly healthy throughout the whole experimental period, and their general appearance was quite good.

The actual increases in live weight per animal, the cost of the ration per week, and the cost per lb. live weight increase, were as follows :—

Season 1916—Average weekly increase in live weight, 7·67 lbs.
,, 1917— ,, ,, ,, 8·40 lbs.
Average over the two seasons, 8·03 lbs.

	1916.	1917.
Average weekly cost of ration, ...	2/-	2/11
Cost per lb. live weight increase, ...	3·14d.	4·01d.

Lot 3.—*Ration: Whey and Palm Nut Meal fed dry.*

As in the case of the other lots, a start was made to replace whole milk with whey and palm nut meal when the calves were three weeks old, and by the time they had reached the age of six weeks the whole milk had been entirely withdrawn.

At that time each calf in this lot was getting about a gallon of whey and ½ lb. of palm nut meal daily. The quantity was steadily increased, and by the end of the experimental period the average daily amount consumed was equivalent to 1½ gallons of whey and 1 lb. of palm nut meal for the whole period.

The palm nut meal was fed dry, and at first the calves did not take very kindly to it, but by adopting the same method as in the feeding of the crushed oats they gradually acquired a liking for it and soon took it quite readily.

Hay and linseed cake were introduced into the ration in exactly the same way as for Lots 1 and 2, hay being fed from the time the calves were five weeks old, and linseed cake from the time they were eight weeks old.

The progress made by the calves was, on the whole, quite satisfactory in both seasons. If anything, the general appearance was not quite so pleasing as that of the calves in

Lots 1 and 2, but there was very little difference. The ration proved a very economical one, the live weight increases being quite satisfactory. They were as follows :—

Season 1916—Average weekly increase in live weight, 7·51 lbs.
,, 1917— ,, ,, ,, 8·31 lbs.
Average over the two seasons, 7·9 lbs.

	1916.	1917.
Average weekly cost of ration, ...	1/7½	2/6¼
Cost per lb. live weight increase, ...	2·57d.	3·64d.

Lot 4 (*Season* 1916).—*Ration: Water and Palm Nut Meal fed dry.*

This ration was given a trial in view of the fairly satisfactory results which had attended its use in the Woburn experiments.

From the age of three weeks on, whole milk was gradually withdrawn and water and palm nut meal substituted in its place, and by the time the calves were six weeks old the whole milk had been entirely withdrawn. The water was thereafter fed *ad lib.*, and the palm nut meal steadily increased as the calves would take it, the amount consumed being equivalent to an average daily allowance of 1½ lbs. per calf per day.

Hay and linseed cake were introduced into the ration in the manner already described.

This ration did not prove a very satisfactory one, the substitution of water for milk being a poor change from the calf's point of view, and even considerably worse than the substitution of whey, which is at least always rich in sugar.

The calves in this lot were all along somewhat unthrifty in appearance, the difference betwixt them and the animals in the other groups being quite marked. Unfortunately the results were affected by the death of two of the animals from "black leg." The remaining two specimens were the best in the group, and the average weekly increase made by them was more satisfactory than the results as a whole really warrant. The average weekly increase (2 animals only) was 7·2 lbs.

Lot 4 (*Season* 1917).—*Ration: Whey, Fine Thirds, and Fish Meal.*

This ration was identical to the one fed to the animals in Lot 2, with the exception that the oat meal was replaced by fine thirds. The fine thirds and fish meal were thus fed in the proportion of two parts thirds and one part fish meal.

The quantity of whey and meals allowed, and the manner of feeding, were exactly the same in all respects as in the case of Lot 2.

No difficulty whatever was experienced in getting the calves to take readily to the ration, and by the time the whole milk was entirely withdrawn they were fully accustomed to the whey plus the porridge made from thirds and fish meal. On the whole, the progress made by the calves in this lot was quite satisfactory, and the ration proved, as regards cost per week, fully the cheapest one in use in 1917.

The average weekly increase was 7·6 lbs.

	1917.
Average weekly cost of the ration, ...	2/5½
Cost per lb. live weight increase, ...	3·88d.

SUMMARY OF RESULTS.

RATION.	Weekly Increase.		Weekly Cost of Ration.		Cost per Lb. Live-weight Increase.	
	1916.	1917.	1916.	1917.	1916.	1917.
	Lbs.	Lbs.				
Separated Milk and Crushed Oats, ...	8·75	8·60	3/8	5/10	5·04d.	8·31d.
Whey, Oat Meal, and Fish Meal, ...	7·67	8·40	2/0	2/11	3·14d.	4·01d.
Whey and Palm Nut Meal, ...	7·51	8·31	1/7½	2/6¼	2·57d.	3·64d.
Whey, Fine Thirds, and Fish Meal, ...	—	7·6	—	2/5½	—	3·88d.

It will be readily apparent from the foregoing summary of results that, while the calves fed on separated milk and crushed oats made fully the best progress, as measured by rate of increase in live weight, the comparative cost of the ration when calculated at current market rates, and the cost per lb. live weight increase rules out that method of feeding where whey is available. Not only so, but in view of the necessity of reserving as much milk as possible—both whole and separated—for direct human consumption, such a method of feeding, however suitable from the calves' point of view, cannot be recommended at the present time.

There is comparatively little difference in the results from the other three rations, and where whey is available quite good calves can be reared with a small quantity of whole milk to begin them. It is specially important that the change from whole milk to whey be very gradually effected. On the whole, the writer, judging not only from the live weight increases but from the general appearance of the calves, prefers the ration consisting of whey, oat meal, and fish meal; but as oat meal is to-day one of our staple human foods, and as the differences in the results from this ration and the other two are not very pronounced, the ration consisting of whey and palm nut meal, or whey, fine thirds, and fish meal, should be given the preference under war conditions, since neither the palm nut meal nor the fine thirds and fish meal are used as direct sources of human food.

Bulletin No. 85.

The West of Scotland Agricultural College.

PRELIMINARY REPORT

ON

ISLE OF WIGHT BEE DISEASE.

BY

JOSEPH TINSLEY, B.B.K.A (First Class).

Glasgow:
Printed by Robert Anderson, 142 West Nile Street.

1918.

PRELIMINARY REPORT ON THE ISLE OF WIGHT BEE DISEASE.

By Joseph Tinsley, B.B.K.A. (First Class).

The Isle of Wight Bee Disease is a highly contagious and deadly malady which affects bees and probably also wasps. This disease, which has long been known on the Continent of Europe, first made its appearance in Britain in 1904; in this year an outbreak was reported in the Isle of Wight, hence the name "Isle of Wight" Bee Disease. It spread with alarming rapidity throughout the country. Few districts or hives escaped its devastating effects, and many beekeepers suffered serious loss. By the year 1912 the stocks of bees in England were reduced to a mere fraction of their original proportions. In some seasons the disease would appear to have been more fatal and to have spread more quickly than in others.

By the year 1913 the Isle of Wight disease was generally established in Scotland; from the southern counties, where it first appeared, the epidemic quickly spread to the northern reaches, leaving death and destruction in its train. In many districts not a single colony escaped, but in certain isolated cases, as in the Kilmaurs neighbourhood, the native bees failed to contract the disease. Such bees appear to possess a natural immunity, and consequently are of great value as foundation stock.

Cause of the Disease.

The first scientific report relating to the etiology of this disease was prepared by Mr. A. D. Imms, and was published in the *Journal of the Board of Agriculture* for June, 1907. The second, written by Dr. Malden, appeared in the *Journal* for February, 1909. The third, by Drs. Graham Smith,

Fantham, Porter, Malden, and G. W. Bullamore, was published as Supplement No. 8 to the *Journal*, and was, in effect, an interim report on the investigation, the final results being published as Supplement No. 10 to the *Journal of the Board of Agriculture*, July, 1913. References to the subject were also made in the Report of the Intelligence Division of the Board of Agriculture and Fisheries, Part II, for the years 1909-12.

In his report of 1909, Dr. Malden ascribes this disease to a bacillus (*Bacillus pestiformis apis*), but in the two papers published by Dr. Graham Smith and his collaborators the disease is definitely stated to be due to a parasitic protozoon (*Nosema apis*). In the 1913 report it is stated: "No species of bacteria constantly associated with the Isle of Wight disease has been found, and *B. pestiformis apis*, which is frequently present in diseased stocks and was at one time thought to be the causal agent, is not pathogenic in pure culture. Bacteria, however, may play an important secondary part in producing the symptoms when the resisting powers have been lowered by the action of *Nosema*."

The disease has more recently been investigated in Scotland by Dr. J. Rennie, of Aberdeen University, and Mr. J. Anderson, M.A., B.Sc., of the Aberdeen College of Agriculture. As a result of considerable experiment and investigation, they conclude that the causative agent is not *Nosema apis*. While admitting that spores of *Nosema apis* may frequently be observed in the bodies of diseased bees, yet they believe that it is not the direct cause of the disease, and that the real source of the trouble is to be found in some other factor which has not yet been determined.

The origin of the Isle of Wight disease has also been made the subject of inquiry by the Beekeeping Department of the West of Scotland Agricultural College. While we do not hold ourselves committed to either of the above views, it certainly does not appear to us that *Nosema apis* is the universal cause of the disease familiarly known as the Isle of Wight Bee Disease. After a thorough examination of the bodies of thousands of bees which have undoubtedly perished from the

Isle of Wight (or at least from a disease all of whose diagnostic features are the same as those of Isle of Wight), we have rarely found the spores of protozoa as described by Dr. H. B. Fantham and Dr. Annie Porter, even after a minute examination of the chyle—stomach and fæces. On the other hand, the stomach contents and the excrement of diseased bees have shown the unfailing presence of masses of bacteria, and we are of the opinion that these are not without special significance.

The result of our work on this aspect of the subject will be published in a later report.

Spread of the Disease.

Apart from the natural agencies which favour the spread of epidemic diseases in general, and which have undoubtedly been operative in the present instance, there is direct evidence of the Isle of Wight disease having been introduced into the various districts of South-West Scotland by the importation of bees from infected areas. It is quite a common practice for beekeepers in Scotland to purchase swarms of bees from the South of England about the month of May, so as to ensure a strong colony for the heather harvest. Many such swarms have come from districts where the Isle of Wight disease was prevalent. These imported bees, though apparently healthy, were in most cases suffering from the disease in its initial stage, when diagnosis is difficult even to the specialist. In the same way, the purchase of queens with attendant workers from infected districts has also materially assisted in spreading the disease.

Once the disease has been introduced into any district it quickly spreads, and sooner or later invades every hive. The infection may take place in several ways.

(*a*) When a colony becomes infected, the stock rapidly dwindles on account of the high mortality incident on the disease. The result is that the surviving members of the colony are too weak to protect the hive against the invasion of robber bees, who carry off the honey and infected material. Not infrequently, also, the dispossessed and overpowered bees

join forces with the invaders, and accompany the robber bees to their own hives. This introduction of infected material, and the association with unhealthy bees, cannot fail to establish the malady in the hives of the reivers, and so it is a case not only of *væ victis*, but also of *væ victoribus*.

(*b*) It is also a well-known fact that bees may enter strange hives in mistake: this particularly happens, during summer, where there is a superabundance of nectar. Such alien bees, if suffering from Isle of Wight disease, can undoubtedly introduce the disease into hitherto unaffected colonies.

(*c*) The practice of sending bees to the heather has also been an important factor in spreading the disease. In this way colonies from many different districts have been brought together on the heather moors. There is no doubt that some such colonies harbour the Isle of Wight disease, probably unknown to the owners, though in some cases colonies which were actually known to be affected have been sent to the heather by beekeepers who fancied a change of environment would result in a cure. When these bees are liberated at the heather after their long journey thither, they frequently mix together, and, in the confusion, often enter the wrong hive. This mingling of members of different hives must be a fruitful cause in the spread of the disease. Observation shows that many colonies suffering from the initial stages of the Isle of Wight disease, when sent to the heather, die there. Even if some do survive the heather season and are brought back to the old home, the evil is only aggravated, for they now become a menace and a plague to their native district.

Symptoms of the Disease.

If one observes a healthy colony in the summer time, the bees will be seen to enter and leave the hive in rapid succession; the laden bees returning from the fields and the workers setting out to collect pollen and nectar do not loiter at the entrance to the hive. They have no time to waste at the gates. They are too busy. But with the onset of the disease there is a marked difference in the behaviour of the bees. They have no longer any desire to toil in the fields.

They seem to have lost their characteristic energy. They crowd round the entrance of the hive, occasionally clustering and displaying a general appearance of listlessness. This lack of vitality is the first noticeable phase of the disease.

A peculiar feature of the wings—the so-called split wing—is often observed in bees suffering from Isle of Wight disease in its early stages. Normally the bee, when in the act of flight, unites the fore and hind wings together so that the two wings on either side of the thorax act as one. (This union is brought about by a series of hooks on the anterior margin of the hind wing engaging a series of catches on the posterior border of the fore wing.) But when the bee contracts Isle of Wight disease this power of union is often lost, and the wings appear quite separate. It should be observed that this split wing appearance, though quite characteristic, is not in itself diagnostic of the disease.

Occasionally a sick bee may be observed drawing its posterior legs over the abdomen—as if the bee realised a sensation of pain in that part.

With the advance of the malady the "crawling" symptoms so typical of the Isle of Wight disease become patent. The diagnosis is now plain, and there can no longer be any doubt regarding the nature of the disease. The crawling symptoms are first noticeable in the sick bees after they have been confined to the hive for two or three days owing to inclement weather. A return to genial conditions or a sudden burst of sunshine will induce the bees to emerge from the hives in great numbers. It will then be seen that many of them have lost the power of flight; some drop down on to the ground beneath the hive where they cluster; others come to earth after a flight of only a few yards. If the hives are situated on grass the bees may be seen crawling up the stems to try and reach a higher position. If the hives stand on ashes or gravel, the bees, by laborious efforts, make their way towards the hive, up the legs of which they crawl in an effort to reach home. The great majority of these bees die, and the ground in the vicinity of the hive becomes strewn with their dead bodies.

An examination of one of these crawlers will show the abdomen greatly distended. This is due to a retention of the fæces, which the insect seems powerless to void. The slightest external pressure will cause a rupture of the intestine and the issue of its accumulated contents. The discharge is usually of a dirty yellow colour, but the colour will be related to the kind of pollen which the bee had previously consumed.

Occasionally the sick bees are able to excrete a portion of the fæces, in which case the front of the hive becomes spotted with the voidings. This gives the appearance of severe dysentery—a malady, however, which does not appear to have any relation to the Isle of Wight disease.

The interior of the hive presents no abnormal appearance in the early stages of the disease. There is no soiling of the combs, and the whole hive appears to be in a healthy and flourishing condition. But with the advance of the disease the soiling of the combs attracts attention. The heavy mortality among the workers so seriously reduces the numbers that the temperature of the hive is lowered and part of the brood dies from lack of heat. After the extinction of the other members of the colony, the queen herself dies. It has been suggested that her death is due to exhaustion and not to the disease. This aspect of the subject, however, will receive attention in a future report.

In winter months the presence of Isle of Wight disease in bee colonies is difficult to determine, for now the bees are in a semi-dormant condition, and are mostly confined to the hive. They rarely fly except on mild days, and consequently there is little opportunity for satisfactorily diagnosing the disease. To make an inspection now would necessitate opening the hive, and this act, on account of the lowering of the temperature, would be harmful to the bees and to what brood there may be. And so, even if the disease could be recognised, no steps can now be taken to check its course.

The beekeeper should know that a colony of bees may enter into winter quarters apparently healthy, strong in numbers, headed by a young queen, and with plenty of food reserves, and yet the total colony may die out during the winter months

from Isle of Wight disease. But as bees may also die during winter from purely natural causes, it becomes important, from the point of view of the well-being of the apiary, to determine to what particular agency, the death of a colony has been due.

In the absence of disease, the extinction of a colony in winter may be due either to loss of queen or to lack of food. In the former case, there will be few, if any, worker bees left alive in the spring : the colony will have perished owing to there being no births to compensate the deaths. On the other hand, a diminution of a colony through lack of food is evidenced by the dead bees clustered on the combs, many with their heads inside the cells. Some of them may be noticed with their tongues extended. The cells will be empty of honey and sugar syrup, but there will be brood in various stages if the bees were alive until the end of January. In neither of these cases is there any soiling of the combs, and there is no objectionable odour.

If, however, the death of the colony has been due to the Isle of Wight disease, the dead bees will be found scattered over the combs and on the floor of the hive ; there will be abundant supplies of food and also a small batch of brood, showing that the queen performed her duties up to the last. But the combs and also the interior of the hive will be soiled with the excreta of the bees. There is a further important distinction in the bodies of bees which have died from natural causes and those which have perished from Isle of Wight disease. Normally the bodies of dead bees shrivel up soon after death, and the abdominal contents will be found to be perfectly dry. But in the case of death due to Isle of Wight disease the intestine is filled with a fluid which gives off a very foul odour. Provided that the body wall is not ruptured, we have found that the intestinal contents will retain their fluid condition for a period of six months. On exposure to air, however, this liquid mass quickly becomes solid.

Infection Experiments.

To illustrate the facility with which the disease can be

transmitted, the following experiments were carried out at our Research Apiary :—

(*a*) About 200 bees crawling on the ground, and showing abnormal distension of the abdomen, were collected, chloroformed, and the liquid contents of the intestine removed. This fluid, mixed with a pint of sugar syrup, was systematically fed to healthy colonies until the crawling symptoms were evident. The colonies thus fed contracted the disease in a virulent form in from three to six weeks.

(*b*) Colonies in the last stage of the disease were united to healthy colonies by placing all the sick bees, combs, brood, and stores in the form of an additional brood chamber over the top of unaffected stocks. (The queens in the diseased colonies were removed previous to the union.) It took from 4 to 6 weeks to transmit the disease by this method.

(*c*) The entire brood chambers from colonies that had recently died from Isle of Wight disease were placed over the brood chambers of healthy colonies (as in the operation of uniting or doubling). The infected brood chambers, which contained fæcal matter in abundance on the frames and over the combs, and many dead bees in the cells, were not interfered with. The chamber was necessarily used by the bees as a honey super. This compelled the healthy bees to remove the dirt and debris from the soiled combs, and brought them in direct contact with disease-infected material. The time of infection in this case was longer—from 6 to 8 weeks.

(*d*) Combs from colonies where the bees had recently died from the disease were broken up and mixed with water. The extract, after being strained through coarse cloth, was mixed with sugar syrup and fed to healthy colonies. In this case infection was even slower—from 8 to 10 weeks.

(*e*) The debris and fæcal matter of the hives of several colonies that had died from Isle of Wight disease was collected by scraping floor boards, frames, &c. This was mixed with water and fed with sugar syrup to healthy colonies. It is doubtful if, in any single case, this method of infection was successful. It should be mentioned that the material was obtained from the hives some time after the death of the colonies, varying from two to twelve months. Presumably the organisms causative of the disease have little vitality outside the bee body, and are killed out by exposure to the atmosphere.

(*f*) Honey extracted from combs upon which diseased bees had died during the winter was given to healthy stocks. These bees did not contract the disease.

Other methods of bringing about infection—such as placing sick bees, numbering from 50 to 500, in healthy colonies; re-queening a healthy colony with a queen from a diseased stock; transferring larvæ and brood from an unhealthy colony to a healthy colony—were tried many times. The results were, in the main, inconclusive.

Although some of the latter methods of infection did not always prove successful, yet from a study of the history and spread of the disease, and of the results of the first experiments outlined above, we must regard the Isle of Wight disease as highly contagious, and beekeepers will be well advised to pay every attention to disinfection of hives and appliances, and to limiting the spread of the disease.

Preventive Measures.

Disinfection of Hives, Appliances, &c.

Hives in which bees have died from the plague should be scraped and thoroughly washed inside and out with a strong solution of formalin (1 in 60). When a large number of hives have to be disinfected, fumigation, properly carried

out, is quite effective, and saves much time and labour. Proceed as follows. Remove the interior chambers, place a lighted formalin candle on the floor of the hive, close up the entrance of the hive, also the cones in the roof. If the latter does not fit tightly, place a sack or covering over it to prevent the escape of the fumes. Leave the gas in contact with the hive for six hours. Finally, wash the exterior of the hive with formalin water (1 in 60).

During a bad attack of Isle of Wight disease many bees will die on the floor and around the stands of the hive, hence it is only reasonable to suggest that, if a fresh position cannot be given to the new colony, the ground on which the hive stands should be liberally disinfected with lime or chloride of lime. All infected combs containing brood and unsealed larvæ should be destroyed. Brood combs that contain honey should be smashed up and the honey used for home consumption. Such honey should not be used for feeding bees.

Frames from a diseased hive may be used again if properly disinfected. To ensure this, first clean out the usual saw-cut in the top of the frame where the foundation is inserted, then scrape away any fæcal matter from the frames, and finally, before placing in the disinfectant, thoroughly scrub them with soap and hot water.

In the same way, empty brood combs, super combs, and sections of comb, can be rendered safe for further service, but here disinfection with formalin vapour is quicker, cheaper, and quite effective. The combs should be placed in a box or other air-tight receptacle, and exposed to the fumes of a sulphur or formalin candle.

Apart altogether from the incidence of the disease, it is an excellent plan to disinfect with formalin all apiary appliances such as feeders, smokers, and queen excluders. Quilts steeped in formalin solution and dried can be safely used again.

Disinfection of the exterior of hives is most easily effected by spraying the outside of the hive with the same disinfectant. A large syringe is very convenient for this purpose. Any of the solution dripping from the outside of the hives will assist in disinfecting the ground on which they stand.

Remedial Measures.

In all our experiments with so-called remedies and cures, it should be understood that the bees, during the period of the experiment, were not confined in any way, and that they were distinctly infected with Isle of Wight disease before any treatment was tried. A number of colonies of diseased bees were purchased from various beekeepers for the purpose of experiment.

Izal.—This proprietary article, advertised as the "Modern high-power germicide, and a reliable remedy against foul brood and Isle of Wight disease," was supplied to (1) a colony suffering from Isle of Wight disease in the initial stage; (2) a colony with a mild attack; and (3) a colony in the last stages of the disease. The Izal was administered both in the food and as a spray with water or sugar syrup, the directions of the manufacturers being carefully followed. In no single case was it effective.

Bacterol.—This bactericide is stated to have a destructive action on spores, and its use has been recommended for Isle of Wight disease. Similar experiments were carried out as with Izal, and the results were the same—purely negative.

Dioxygen, Phenol, Quinine, Formalin, Sulphur, *Milton*, &c., also aperients, were experimented with, but all gave negative results. Indeed, it is doubtful whether a medicine or drug exists which, when administered to bees suffering from the Isle of Wight disease will effect a cure. We think little is to be gained by the search for a so-called specific among medicines or chemicals. Recently Flavine has been tried, but without any good results.

The most promising results so far obtained by us have been got from the employment of a pure culture of *Bacillus Bulgaricus*. This is the organism recommended by Prof. Metchnikoff as a remedy for intestinal troubles. It acts as a scavenger of the intestine, and displaces putrefactive and injurious organisms in the bowels.

The method was first tried by us during the latter part of July, 1916, at the suggestion of Prof. Renwick H. Leitch (Dairying Department, West of Scotland Agricultural College), who also supplied the culture. The culture was mixed with syrup and fed to the bees by means of spraying. The bees will readily take the food in the feeders, but spraying is the quicker method. The treatment was tried on a swarm of bees which arrived from the South of Scotland on the 27th July, 1916, and which on arrival almost immediately developed a virulent attack of Isle of Wight disease. The swarm weighed seven pounds. It was placed on ten frames, which had previously been fitted with brood foundation. In the course of two days the whole of the ten combs had been built, the cells being filled with nectar, pollen, and eggs of the queen. On the 30th July it was noticed that, on the ground in front of the hive, the bees were crawling about in hundreds. The entrance to the hive was closed the same evening, and the colony removed from the Holmes Farm Apiary (where it was first placed) to the Research Apiary—about 2 miles distant. On the bees being liberated the following day, external indications of the disease were even more pronounced, probably owing to the confinement of the bees during transit. By this time there was a disease in the population of at least 30 per cent The *Bacillus Bulgaricus* was administered on the evening of their arrival, by spraying both at the entrance and over the tops of the brood combs. The number of crawlers decreased each day, and finally disappeared altogether after a fortnight's treatment. The culture had a noticeable effect, not only on the expulsion of the fæcal accumulation, but also on the nature of the discharge. There is less tendency for the excretion to solidify; after it has been voided it rather tends to break up. Ordinarily the colour of the fæces in cases of Isle of Wight disease varies in summer from a light yellow to a dark brown. The *Bacillus Bulgaricus* changes it to a dark grey. The colony thrived during the autumn and winter, and remained alive until early in the spring.

It would appear, from the supplementary evidence of

experiments with other colonies, that this treatment, while it may not result in an absolute cure, will at any rate for a time repress the disease and even check mortality during the summer months. It is possible that, if the treatment be begun early and be continued systematically, it may entirely ward off the disease. There are certainly possibilities in the use of this culture, and further experiments are being carried out.

Breeding to Produce Immunity.

The real remedy for this disease lies in the production or development of strains of bees immune to it. It is a well-known fact that some strains of bees are highly resistant to the Isle of Wight disease, and can only be caused to contract it by the direct administration of considerable doses of infected material.

During the course of our infection experiments we observed that certain selected colonies failed to contract the disease even under conditions most favourable to infection. Their powers of resistance were so marked that we decided to retain them for the purpose of raising queens and the increase of stock generally, and further to use them as a basis for our experiments in the production of disease-resistant strains of bees. In this attempt to produce immunity, purely scientific methods were employed. The scheme, which started on a limited scale, has now been greatly extended, so that an apiary of considerable size has been built up at our head-quarters, Kilmarnock.

To determine whether the bees so bred are largely disease-resistant, colonies were placed, during 1916, in the very heart of districts in Ayrshire where the disease had been rampant for five years, and where all attempts at re-stocking had utterly failed. During last season (1917) each experimental colony gave a swarm and a cast, or second swarm, and in addition produced a good yield of honey. Up to the present, the colonies are quite free from disease.

In our efforts to raise immune strains we have experimented very largely with foreign bees. Generally speaking, we have

not found them to be disease proof, although, when attacked by the disease, they do not succumb nearly so quickly as native stocks. Particularly was this the case with Dutch, Italian, American, and Punic bees. There is no doubt that judicious crossing of foreign bees with our own tends to increase vigour and disease-resisting powers. We observed this particularly in the case of Dutch crosses.

It will also generally be found that foreign bees imported from districts which are low-lying and wet, and where there is a lack of sunshine, will give the best results in withstanding the disease; at least this has been our experience.

With regard to resistant strains of native origin, it may be interesting to observe that the smaller-sized bees appear to have greater disease-resisting powers than larger-sized bees. These hardy little bees are often to be found living in trees in woodlands, and in the roofs of castles and houses.

The work on the production of immune strains of bees is being continued, and it is hoped that we shall shortly be in a position to re-stock disease-swept districts in the College area from our apiary at Kilmarnock.

ULLETIN No. 86.

West of Scotland Agricultural College.

REPORT

ON

DEMONSTRATION POULTRY CROFTS

AT

ISLAY, TIREE, and GLENLUCE,

BY

THE COLLEGE INSTRUCTRESSES

FOR THESE DISTRICTS.

GLASGOW:
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1918.

Report on Demonstration Poultry Crofts.

The College, having in view the necessity for the adoption of modern and profitable methods of poultry-keeping, especially amongst crofters, cottagers, and small holders, made arrangements in January, 1915, for the establishment of a few Demonstration Crofts in the more remote areas served by the College. These crofts were equipped with modern houses and pure-bred stock likely to suit the locality, and provision was made by the College for their periodical inspection and general supervision by the instructresses in poultry-keeping for the districts in which they were established.

Two crofts were selected to begin with—one in Islay and the other in Jura.

Unfortunately both places have had to be discontinued on account of the poultry-keepers being called up for service, but in the case of the Islay croft one year's working results have been obtained.

At a later date two other demonstration crofts were started, one being in the Island of Tiree and the other in Glenluce, managed in both cases by the wives of the crofters.

Islay Croft.—January to December 31st, 1915.

20 White Wyandottes and 12 White Leghorns.

Receipts for eggs, ...	£24	15	6
Expenditure, ...	10	9	4
Profit, ...	£14	6	2=8s. 11d. per bird.

Average price of eggs, 1s. 3d. per dozen.

The White Wyandottes were kept on the Colony system, the size of house being 8 feet 6 inches by 6 feet 6 inches; the White Leghorns in a permanent house of the same dimensions, enclosed in a wire-netted run.

The Colony house was removed from time to time to fresh ground, and in the autumn was placed on the stubble. During this period the stock required little or no hand-feeding; moreover, they benefited greatly from the run in the stubble, and this led to better results as regards winter egg production.

The houses, partially open-fronted, had canvas shutters, which could be closed during stormy weather, a window at the end providing light.

The window was sufficiently low down to throw all the light possible on the floor, so that the birds could see to scratch for their food when the shutters were closed.

The nest-boxes were fixed across the front of the house, so that no floor space was wasted. They were fairly deep and as dark as possible. Unless the boxes are dark there is a tendency to egg eating.

The permanent house had no wooden floor such as was provided in the movable one, but was placed on a prepared earth foundation.

A dropping board beneath the perches allowed the whole floor to be used for scratching purposes.

The enclosed birds were fed three times daily—soft mash in the morning, a small feed of grain at mid-day, and a full feed in the evening.

During the winter the order was changed, grain being fed morning and mid-day and soft mash at night. This method was found to be very satisfactory, as it kept the birds active during the earlier part of the day.

All food was fed inside the house, the soft mash being given in V-shaped troughs, made sufficiently long to allow all the birds to feed at the same time.

The grain was buried amongst the litter, which consisted of chaff and broken straw, covering the floor to a depth of 5 or 6 inches. Warm water and greens or raw turnips were supplied during winter and early spring, and a plentiful supply of grit was got from the shore free of cost.

The birds were kept confined to the house during frost and in stormy weather, and the houses were kept scrupulously clean.

TIREE DEMONSTRATION CROFT.—1915.

It was decided to begin by rearing the stock on this croft, instead of by purchasing it, and to keep an account of the cost from the shell to the laying period. The particulars are as follows :—

1915.—March to 30th September, on which date pullets were housed.

60 chickens reared—36 kept for stock (19 Rhode Island Reds and 17 Black Leghorn Pullets).

Expenditure.				*Receipts.*				
Sittings of Eggs, -	£0	12	4	7 Cockerels at 2/,	£0	14	0	
Grain, - -	2	11	3	7 do. „ 1/9,	0	12	3	
Meals, - -	2	12	9	9 do. „ 1/3,	0	11	3	
Sundries, - -	0	0	10					
					£1	17	6	
				Eggs laid in Sept.—				
				30 Eggs at 1¼d. each,	0	3	1½	
				27 do. „ 1½d. „	0	3	4½	
	£5	17	2		£2	4	0	

The actual expenditure amounted to £3 13s. 2d., which works out at 2s. per pullet kept for stock.

The birds were fed on biscuit meal, bran, thirds, oatmeal, wheatmeal, and buttermilk ; alternately with dry seeds consisting of cockle wheat, groats, cracked Indian corn, broken rice, and dari. Biscuit meal was discontinued after the fourth week. Coarser feeding and oats were fed as they grew up.

The chickens were hatched and reared by hens, the latter being kept confined to roomy coops, and after the first few days the chickens were all fed together at some distance from the coops.

The hens got ordinary rations, clean water, grit, and fresh grass being always within reach.

Great care was taken that no chicken food was wasted; any left after the chickens were satisfied was removed. As a rule, it is not the food eaten by the chickens but what is wasted that brings up the cost of rearing.

Chickens reared in this way become very hardy and independent.

It may be mentioned that the coops were made from grocery boxes, and answered the purpose excellently. Lime-washed inside, sparred in front, with a sanded floor kept thoroughly clean, they make very comfortable quarters.

Laying Results of Pullets.

1st October, 1915, to 30th September, 1916.

36 Fowls, consisting of 19 Rhode Island Reds and 17 Black Leghorns.

Eggs laid by Rhode Island Reds, ... 3,706
Average, 195 per bird.

Eggs laid by Black Leghorns, ... 3,217
Average, 189 per bird.

Receipts for eggs,	£45	8	2¼
Expenditure, ...	20	6	4
Profit, ...	£25	1	10 = 13s. 11d. per bird per ann.

Average price received for eggs, 1s. 7d. per dozen.

1st October, 1916, to 30th September, 1917.

49 Fowls, consisting of 18 Rhode Island Reds (2nd season), 14 Rhode Island Red pullets, and 17 Black Leghorns (2nd season).

Eggs laid by Rhode Island Reds, ... 3,810

Average, 119 per bird.

Eggs laid by Black Leghorns, ... 1,933

Average, 113 per bird.

Receipts, ...	£54	8	$1\frac{3}{4}$
Expenditure, ...	33	0	9
Profit, ...	£21	7	4=9s. 6d. per bird.

Average price per dozen, 2s. $0\frac{1}{2}$d.

It is clearly more profitable to have pullets when the eggs are only sold for marketing purposes. A small pen of first-cross birds, the progeny of 1916-17 Rhode Island Reds and Black Leghorns, gave the following results :—

January, 1917, to 30th September, 1917.

8 Cross-bred Pullets.

Eggs laid, 1,070. Average per bird, 133 (9 months).

Received for eggs, ...	£9	0	0
Expenditure, ...	5	14	9
Profit, ...	£3	5	3=8s. 11d. per bird.

The Black Leghorns were kept on the semi-intensive system, and never allowed out of the house in bad weather.

Both breeds were enclosed in wire-netted runs facing the Atlantic. The houses were fastened down with wires attached to posts driven into the ground. They were provided with open fronts, as already described, but were fitted with double canvas shutters in winter.

The Rhode Island Reds, being in a movable house, were drawn on to the stubble after the crops had been secured, and this helped to keep down the food bill.

The first-cross birds were allowed a free run.

The following is an example of the rations used in 1916 :—

For 20 Fowls.

Morning Mash.—8 oz. bran (scalded), 8 oz. thirds, 2 oz. oatmeal or ground oats, 2 oz. potatoes or turnips (well mashed). Buttermilk, when available, was given to drink.

Mid-day and Evening—Grain.—The grain fed was principally oats, occasionally a little wheat was added, and in winter some Indian corn. The quantity of grain allowed was about 1 lb. at mid-day and $2\frac{1}{2}$ lbs. in the evening.

Green stuff and raw turnips were supplied constantly throughout the winter and when grass was scarce.

Plenty of shell grit is got from the shore, but all feeding stuffs have to be shipped from Glasgow, including oats, the high freight charges adding considerably to the cost.

Sand is used for covering the dropping boards. The droppings being removed daily, the houses are spotlessly clean, and a clean poultry-house ensures clean nests and eggs and keeps the birds free from vermin.

The rations were altered for 1917; more potatoes and turnips being fed in the soft mash and less grain given. Oatmeal was entirely stopped, but ground oats could still be had, and were used sparingly in the mash.

Glenluce Poultry Croft.

Owing to the time of year at which the Glenluce croft was started it was found difficult to procure pullets, and second-year birds (Rhode Island Reds and Black Leghorns) were obtained instead. The birds purchased, while of a good laying strain and very suitable for breeding purposes, did not give the high average egg yield obtained from pullets.

Some of the hens considered to be extra good layers were retained in their third season, but this can only be justified in exceptional circumstances, and, as a general rule, is not to be recommended.

The housing provided was of the type described in the case of the other demonstration crofts, but, in view of the advisability of keeping pullets and second-season birds in separate houses, an extra house has now been procured for this croft, and in future one house will be reserved for the pullets.

Particulars regarding returns are as follows:—

January to September 30th, 1916.

24 Rhode Island Reds (2nd season birds). 15 Black Leghorns (2nd season birds).

Receipts for eggs, ...	£33	13 8
Expenditure, ...	16	12 4
Profit, ...	£17	1 4 = 8s. 9d. per bird.

65 dozen eggs were sold at 3s. per dozen for hatching purposes, and the rest were sold locally at an average of 1s. 4d. per dozen.

Ration for 38 Fowls.

Morning.—Bran, 12 oz.; thirds, 8 oz.; ground oats, 8 oz.; boiled fish-heads, &c., 10 oz.

Mid-day.—Oats or wheat, 38 oz.; in winter steamed and fed warm.

Evening.—Oats, wheat, and Indian corn, equal parts, 57 oz. = $1\frac{1}{2}$ oz. per bird.

Results from 1st October, 1916, to 30th September, 1917.

72 Birds. Rhode Island Reds and Black Leghorns.

Eggs laid, 7,077; average, 99 per bird.

Receipts, ...	£71	9	2½
Expenditure, ...	50	2	6
Profit, ...	£21	6	8½ = 5s. 11d. per bird.

59 dozen were sold as settings, at 3s. 6d. per dozen.

The pullets and hens were fed on rather different rations, and to bring the pullets on to lay a little extra soft food was fed at night.

Morning Mash.

	Hens.	Pullets.
Bran, ...	8 oz.	6 oz.
Bulko, ...	5 „	3 „
Cut oats, ...	5 „	4 „
Thirds, ...	8 „	4 „
Potatoes, ...	8 „	3 „
Fish meal, ...	14 „	7 „

Mid-day.

Oats, ...	3 lbs.	1 lb. 12 oz.

Evening.

Mixed grain, ...	4½ lbs.	2 lbs. 8 oz.

Grain Fed in Litter.

All fowls were allowed greens and a turnip cut in half, as a proportion of vegetable food is very necessary to the health of the birds. A constant supply of grit was provided.

At the end of the hatching season (about end of May) the pens were broken up and all male birds sold off, the advantage of this being that the eggs keep fresher and food is saved.

No cropping is carried out on this croft, so that the birds had not the advantage of stubble, and the feeding bill was higher on that account. This will be remedied next season, as it is proposed to sow oats in one of the fields.

Cost of chicken rearing on Glenluce Croft is given below :—

1916.—*Amount of Food consumed by Chickens.*

Biscuit meal, 56 lbs.; cockle wheat, 56 lbs.; groats, 21 lbs.; bran, 112 lbs.; thirds, 126 lbs.; oatmeal, 147 lbs.; dari, 56 lbs.; oats, 441 lbs.; Indian corn, 56 lbs.; broken rice, 28 lbs.

Cost of rearing 110 chicks, ...	£6	19	2
Eggs for hatching, ...	3	9	6
Total cost, ...	£10	8	8

Average cost, 1s. 10¾d. each.

58 pullets kept for stock purposes.

52 cockerels sold at 2s. 3d. to 3s. 3d. each = £7 2s.

Deducting this sum from the cost of rearing reduces the cost per pullet to about 1s.

The chickens were hatched by hens, but the hens were confined in coops and the chicks fed apart after the first few days.

Cost of Rearing in 1917. *(Glenluce.)*

Chicks hatched, 114.

The chickens were hatched in an incubator and reared in brooders.

Feeding Stuffs used.—Biscuit meal, 224 lbs.; broken rice, 70 lbs.; groats, 91 lbs.; oatmeal, 35 lbs.; thirds, 105 lbs.; bran, 28 lbs.; cockle wheat, 56 lbs.; meal seeds, 14 lbs.; dari, 89 lbs.; cracked Indian corn, 168 lbs.; potatoes, 28 lbs. Carriage

on goods, 5s. 1d. Total cost (94 chicks), £13 1s. 2d. Average cost of feeding, March to August, 2s. 9d. each.

47 cockerels sold at 2s. 6d. to 3s. 4d. each,	£6	10	0
14 pullets sold at 5s. each, ...	3	10	0
	£10	0	0

33 pullets kept for stock.

These demonstration poultry crofts appear to be serving a very useful and educative purpose. Great interest is taken in them by poultry-keepers in the district in which they have been established, and they have been visited by numbers of people, who see the results for themselves, and to whom the methods of working are fully explained.

BULLETIN No. 87.

West of Scotland Agricultural College.

SMALL-HOLDER'S CHEESE.
SKIM-MILK CHEESE.
COTTAGE CHEESE.

BY

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SMALL-HOLDER'S CHEESE.

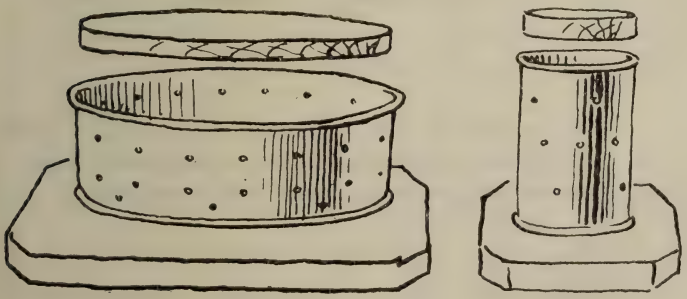
THE essential appliances for the manufacture of a Small-holder's Cheese are :—

(1) *Steel Drum*, *Oaken Tub* or *Cask*, or for small quantities of milk an *Enamelled Pail*. A wooden tub, if used,

FIG. 1.

must be smooth inside and of a deep shape. A steel drum holding 10-15 gallons costs 15s. to £1.

(2) *Hoops* or *Moulds*, made of tinned steel, with perforations in the sides. Each mould rests on a wooden



Shallow & deep Moulds
with Board & Follower

FIG. 2.

board, and is provided with a closely-fitting wooden disc or follower. These moulds are commonly sold in 3 sizes, costing 7s. 6d., 6s., and 5s., complete with board and follower.

(3) *Knife* and *Skimming Dish.*—The knife is required for cutting the curd into cubes. It should have a long

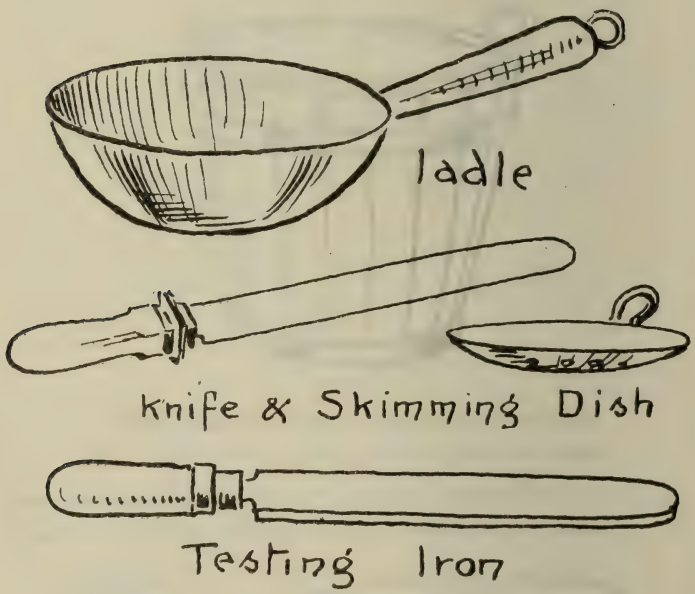


Fig. 3.

blade—costs 5s. 6d. A bread knife may be used. An ordinary skimming dish, which should have a sharp cutting edge, may be used in association with the knife.

(4) *Draining Rack.*—This consists of a sparred frame, resting in a wooden box or trough which is provided with a plug to allow of the escape of whey. A convenient size of trough is 24 inches by 18 inches by

6 inches deep. The rack is made to fit this exactly. Such a draining rack will accommodate the curd from 10 to 15 gallons milk, and is easily constructed. (See illus.)

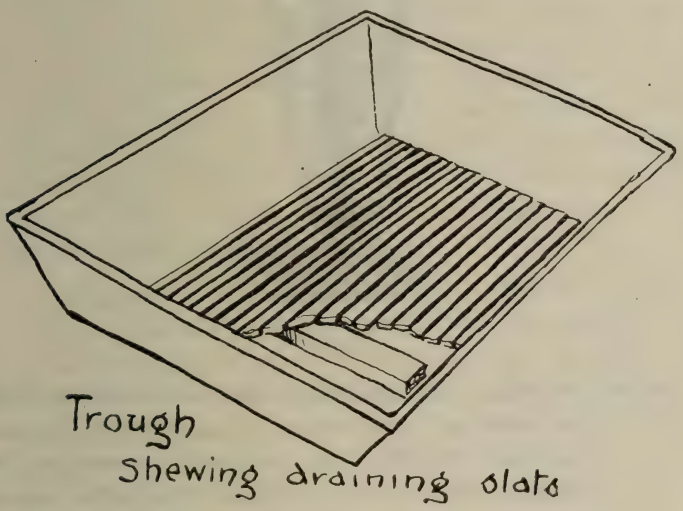


Fig. 4.

(5) *Testing Iron.*—A flat bar of mild steel, 1 inch broad and about 12 inches long, and fitted with a wooden handle—costs 2s. A poker or any steel bar will do quite well.

(6) *Thermometer.*—An indispensable adjunct. A floating dairy thermometer is most convenient, but at present is scarcely obtainable; a good wall thermometer may be used instead, but it must be kept clean—costs 4s. 6d.

(7) *Measuring Glasses*, 4 oz. and 1 drachm, for measuring the rennet and starter. These are not essential if the

following points are remembered:—1 teacup holds 4 oz., 2 tablespoons = 1 oz., 1 teaspoon = 1 drachm.

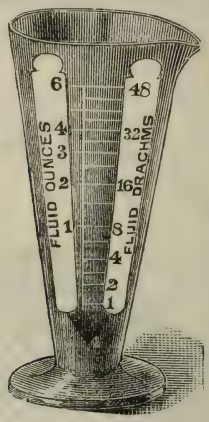


Fig. 5.

(8) *Cheese Cloths* and *Bandaging Materials*.—Cheese cloths are made of coarse cotton, measure 1 yard square, and cost 2s. 6d., The material for covering the finished cheese is made of fine cotton fabric, costing 10d. per yard (54 inches wide).

(9) *Rennet*.—Absolutely essential. A good brand should be used. Such may be obtained from Professor R. H. Leitch, Dairy School, Kilmarnock, at a cost of 1s. 6d. (post free) for a four-ounce bottle: this is sufficient to coagulate 80 gallons milk.

(10) *Starter*, or *Lactic Ferment*, may be had from the Dairy School at 1s. 6d. per 6-oz. bottle. If properly handled, should last for a month. The use of a good starter for Small-holder's Cheese is strongly advocated.

Dairy Appliances are obtainable from Walker & Templeton, Kilmarnock.

PROCESS OF MANUFACTURE.

Care of Milk.

Milk intended for cheesemaking should be produced under strictly clean conditions. The wiping of the cow's udder and flank with a damp cloth just before milking, the washing of the milker's hands before milking each cow, the rejection of the first few streams (fore milk), and the use of clean utensils, are factors of supreme importance in the production of the cheese milk. No colostrum (beistings), old milk, or milk in any way abnormal should be employed. The fresher and the purer the milk used, the finer will be the flavour and the better the quality of the finished cheese.

Small-holder's Cheese is of two types—(*a*) that in which the whey is heated during the process of manufacture, and (*b*) that in which the curd is ladled out but in which no scald is used. For convenience, the first will be referred to as the "Scalded Type," and the second as the "Ladled Type." The scalded type gives a better quality of cheese and one which keeps well. The ladled type is ready for consumption sooner, but does not keep so long as the other. But if care be used, either method produces a very satisfactory and palatable article.

Synopsis (Small-holder's Cheese, Type A).

1. Cool the evening's milk to 70° F. Add the morning's milk, and bring to a temperature of 84° F.

2. Add the starter, and ripen for $1\frac{1}{4}$ to $1\frac{1}{2}$ hours.

3. Rennet at 84° F. (1 ounce to 20 gallons).

4. After cutting the curd, scald to 92° F. by heating part of the whey.

5. Run off the whey when the hot iron draws threads $\frac{1}{8}$ inch long.

6. Drain the curd on the rack, bundling and weighting it.

7. Mill when threads from $\frac{1}{2}$ inch to $\frac{3}{4}$ inch are observed.

8. Salt the curd and pack it into moulds.

9. Press and cure the cheese.

Type A—Scalded Type.

As a rule the milk of two successive milkings is employed, and in practice gives the best results. (The milk of a single milking may be quite well made into cheese, but if quite new it should be allowed to "ripen" for some time before the rennet is added—usually about two hours.) The evening's milk is strained into the drum or tub, and cooled to a temperature of about 70° F. by stirring it and circulating cold water round the vessel. The morning's milk is added to this, and the temperature of the mixed milk brought to that of renneting (84° F.). This is usually effected by removing a portion of the milk in a clean pail and heating it in hot water. Avoid heating such milk to a temperature over 110° F.

Adding the Starter.

The starter is added to the evening's milk in the morning at the rate of 1 oz. (*i.e.*, $\frac{1}{4}$ teacupful) per gallon of milk, and the milk well stirred.

Starter is simply pure sour milk specially prepared, and contains the lactic acid germs in a vigorous condition. The

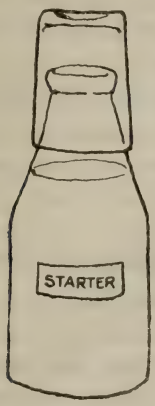


Fig. 6.

quality of the ripe cheese is largely dependant on an intelligent use of this ferment. Starter, when obtained from the Dairy

School, should be kept going in the following manner :—Take some fresh skim or separated milk (or new whole milk) in a clean milk bottle, plug the mouth with cotton wool (or loosely tie a piece of paper or place a tumbler over the mouth), place the bottle in a pan of cold water, and bring the water to the boil. Keep the milk at the boiling point for five minutes, and then allow to cool slowly. When the temperature reaches 90° F. introduce some of the starter, plug the mouth again, and keep the bottle at the room temperature until the starter has thickened. Then remove to a cool place, or stand the bottle in cold water until required. This should be done daily. See that the starter bottle is kept thoroughly clean, and that the starter is kept away from the direct rays of the sun.

Ripening the Milk.

After the addition of the starter, the milk is allowed to ripen for $1\frac{1}{4}$ - $1\frac{1}{2}$ hours, until ready for renneting. During ripening the milk should be stirred occasionally to prevent the cream rising.

Renneting the Milk.

Rennet is now added at the rate of 1 drachm to $2\frac{1}{2}$ gallons milk. The rennet should be diluted with 6 times its volume of cold water, and thoroughly stirred in for 3 minutes. The temperature of the milk at renneting should be 84° F. The vessel should then be covered with a clean cloth and left untouched until coagulation is complete. This usually takes about 40 to 50 minutes.

Cutting the Curd.

When ready for cutting, the curd should split under the finger with a clean fracture, or come away clean from the side of the vessel when the curd surface in the vicinity is pressed with the back of the hand. The cutting is done with the long-bladed knife alone or in association with the skimmer. The aim should be to cut the curd uniformly into $\frac{1}{4}$-inch cubes. The more even the cutting and the greener the

whey, the better will be the result. Cut the curd lengthwise and crosswise, first vertically and then horizontally. The vertical cutting is performed with the knife; the horizontal cutting, when small quantities of milk are being handled, can be done quite well either with the knife or with the skimming dish, but where larger volumes are being

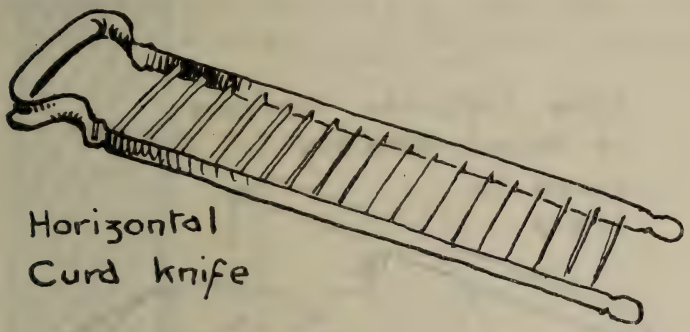


Fig. 7.

manipulated it is best performed with a special knife with parallel horizontal blades, costing 10s. 6d. (See illus.).

After cutting, the curd is stirred in the whey for 10 minutes, and then allowed to settle for about 5 minutes. During coagulation the temperature will have fallen to 81-82° F.

Scalding or Cooking the Curd.

A portion of the whey—about a $\frac{1}{4}$ of the total volume in the tub—is now removed in a clean pail, heated to 100° F., returned to the making vessel, and stirred for 10 minutes. This will raise the temperature to 86-87° F. A second portion of the whey is removed in a like manner, heated to 110°, and returned to the tub. After stirring for 10 minutes the resultant temperature should be 92° F. If this temperature is not reached the process of heating the whey is repeated. After scalding is complete, hand stirring is continued until the curd feels firm, assumes a bright or glistening appearance, and tends to sink rapidly in the whey. This stage is usually reached about an hour after cutting. The curd is then settled

in the whey, and is allowed to lie undisturbed for 20 to 30 minutes, or until acid enough.

Drawing the Whey.

The whey is removed from the curd when the latter begins to draw fine silky threads on the hot iron. In point of time, this operation usually takes place about $1\frac{3}{4}$ hours after cutting the curd. To carry out the test properly the testing iron or

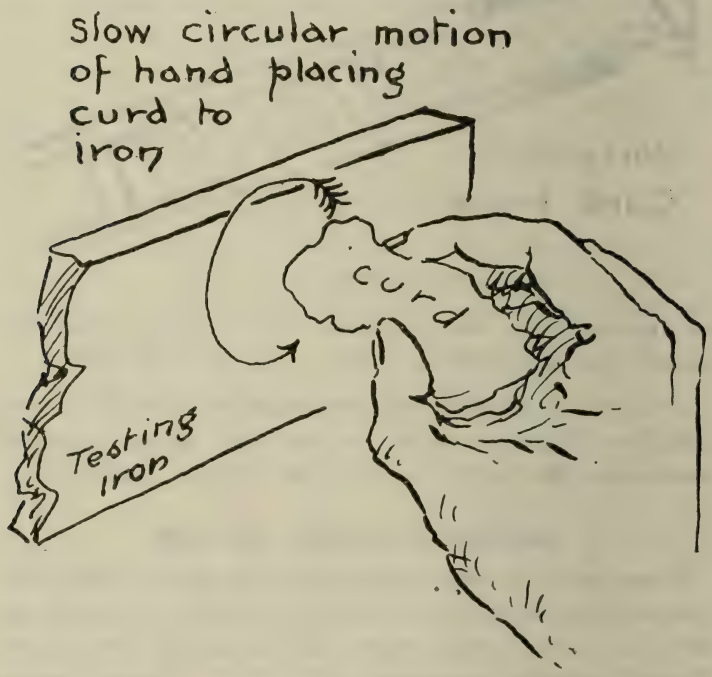


Fig. 8.

poker should be heated in the fire until it is red, and then cooled to a black heat. A piece of curd which has been well squeezed in the hand is applied to the hot iron until it adheres, and then gently withdrawn. If fine silky threads $\frac{1}{8}$th of an inch long are observed, the whey may be siphoned or baled off. It is important that the whey be not removed from the curd until this test is obtained.

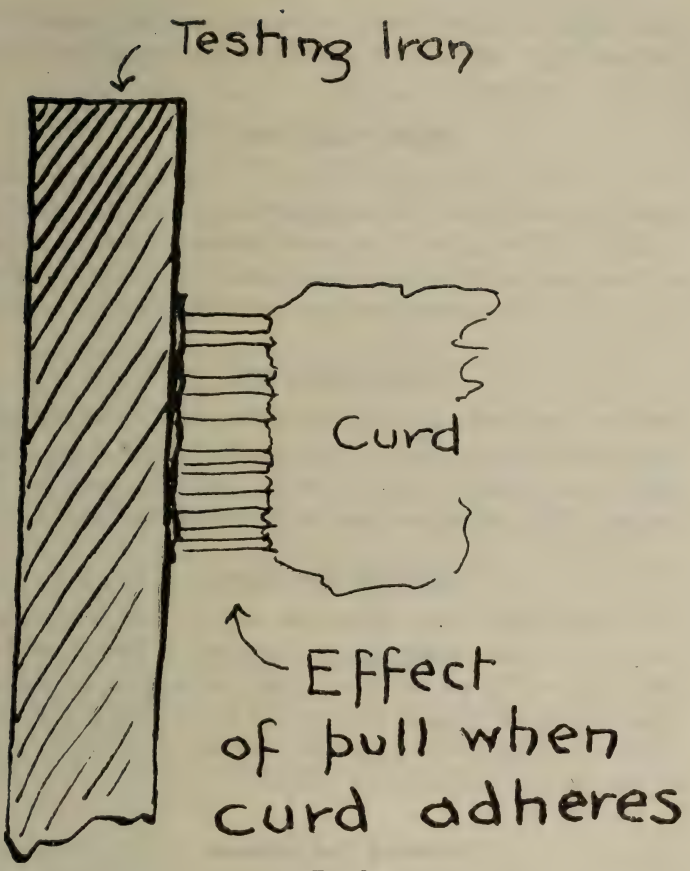


FIG. 9.

Draining the Curd.

When most of the whey has been removed, the curd is transferred to the rack, which is covered by a coarse straining cloth, and stirred with the fingers from 3 to 5 minutes to free it from excess of whey. Then bring the curd together in an even layer of uniform depth (about 3 inches), and cover up with a dry cloth.

When the curd has matted into a solid block (20 minutes after), it is cut into 4-inch cubes, tied up in a bundle, and

lightly weighted. The bundle is opened up, the cubes torn apart and rearranged, and the bundle re-tied every 20 minutes until fit for milling.

Milling the Curd.

When the hot iron shows threads $\frac{1}{2}$ inch to $\frac{3}{4}$ inch long (about $1\frac{1}{2}$ hours after drawing off the whey) the curd is "milled." This simply means that the curd is broken up by the hand into small pieces about the size of walnuts. After milling, the curd should be stirred, to aerate it and to cool it.

Salting the Curd.

Salt is now evenly sprinkled over the curd, at the rate of 1 oz. to every $3\frac{1}{2}$ lbs. curd. Use a good brand of dairy salt, apply it uniformly, and thoroughly stir the curd for 5 minutes. Then allow the curd to stand for 10 minutes.

Moulding the Curd.

The mould into which the salted curd is now transferred rests on its wooden board, and is lined with a freshly-scalded cloth. The curd is packed evenly into the mould in successive layers, and firmly pressed down by the hand. When full, the ends of the cloth are brought over the top of the curd, and the follower (or circular disc) put on.

Pressing the Cheese.

The pressure may be applied by a series of weights, but these are unnecessary if the lever principle of pressing be

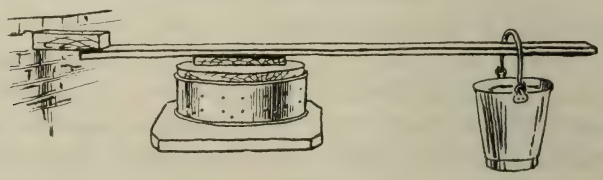


Fig. 10.

employed. The mould containing the curd is placed on a wooden block, and pressure brought to bear on it by means

of a wooden bar, one end of which is inserted under some projecting ledge, while the other arm carries a pail weighted with stones. The pressure is gradually increased by moving the weighted pail towards the end of the lever. See that the lever bears evenly on the follower.

If the curd, under pressure, sinks below the rim of the mould, so that the lever bar rests directly on the mould, a small flat block of wood may be placed on the top of the follower to take the pressure of the lever.

In the evening, remove the cheese from the hoop, wring out the cloth in hot water, reverse the position of the cheese, and return it to the press. Next morning, put on a fine dry cloth and again return to the press. Pressure should be continued for two full days if a good finish is desired. On the completion of pressing, the surface of the cheese is greased with lard (or substitute), circular caps of fine cotton put on the ends, and finally a tight bandage sewn on the side.

Curing the Cheese.

The cheese should be cured for 6 to 8 weeks, or until it is ripe. During the curing process it should be kept in a well-ventilated room, the temperature of which is from 55° to 60° F., and turned daily.

A cheese of this type, when well made, will keep for several months without becoming sharp or bitter in the flavour.

Synopsis (Small-holder's Cheese, Type B).

---

1. Ripen the mixed evening and morning milk with starter.
2. Rennet the milk at 90° F.
3. Cut and ladle the curd into draining cloth.
4. Lightly tie the free ends of the draining cloth and tighten from time to time to facilitate drainage.
5. Complete drainage by cutting the curd when firm enough into cubes and bundling.
6. Mill when threads $\frac{1}{2}$ inch are observed.
7. Salt and mould the curd.
8. Press and cure the cheese.

Type B—Ladled Type.

This method is adapted for making smaller quantities of milk into cheese, and is perhaps better suited than the previous method for dealing with second-class milk.

The appliances required are, in the main, the same as those already indicated, *i.e.*, Making Vessel (Drum, Tub, or Pail), Moulds, with Board and Follower, Ladle (or Skimming Dish) with sharp cutting edge, Draining Rack (or Milk Basin), Testing Iron, Thermometer, Measuring Glass, Rennet, Starter, and Cheese Cloths.

(*a*) The evening's milk is strained into the pail or making vessel, and cooled by stirring to 70° F. One drop of starter may be added in the evening. Next morning the cream is stirred down and the morning milk run in.

(*b*) Starter at the rate of 1 oz. per gallon is added to the mixed milk, the temperature of which should be immediately raised to 90° F.

(*c*) The milk is allowed to ripen for 1 - $1\frac{1}{4}$ hours, being occasionally stirred to prevent the cream rising. The temperature should be maintained at 90° F. throughout: if it falls below this, it should be brought back by heating a portion of the milk.

(*d*) On the completion of the ripening process, rennet is added at the rate of 1 drachm to 2 gallons milk. Dilute the rennet with cold water, and stir in for 4 minutes.

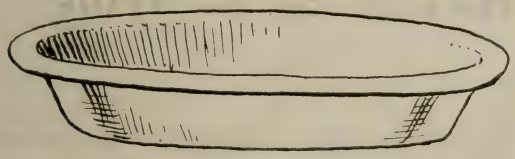


Fig. 11.

(*e*) When the milk has coagulated, the curd is cut vertically into 1-inch squares with the knife, and then ladled out in thin slices into a coarse cloth resting in a draining rack, or, what is equally good, a milk basin.

(*f*) When all the curd has been ladled out, the corners of the cloth are brought together and lightly tied. The whey,

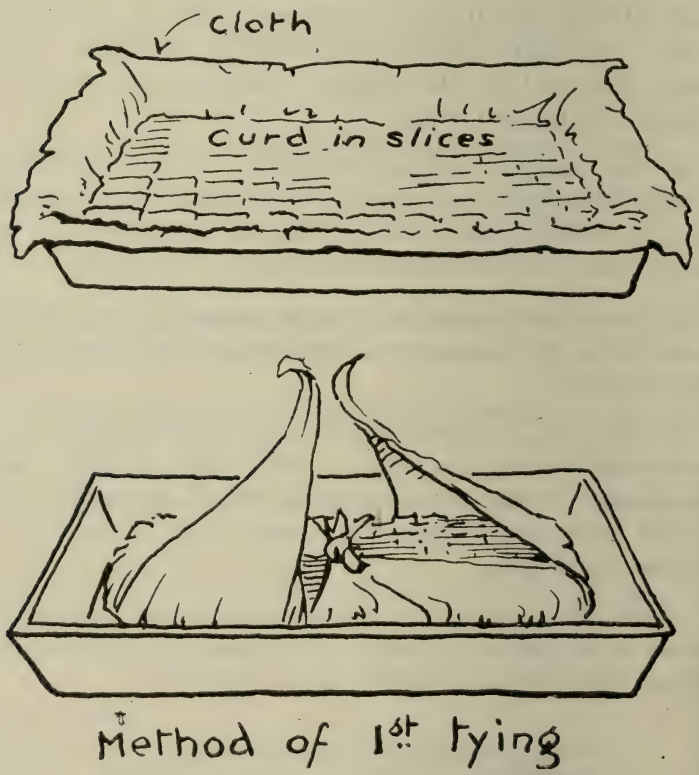


Fig. 12.

as it drains from the curd, accumulates in the pan and is run off by tilting the latter. As the whey drains away the curd contracts, and consequently the cloths should be tightened every 15 to 20 minutes. After the third tying it will usually

be found that the bulk of the loose whey has been expelled, and that the curd has lost its sloppy consistency. With the

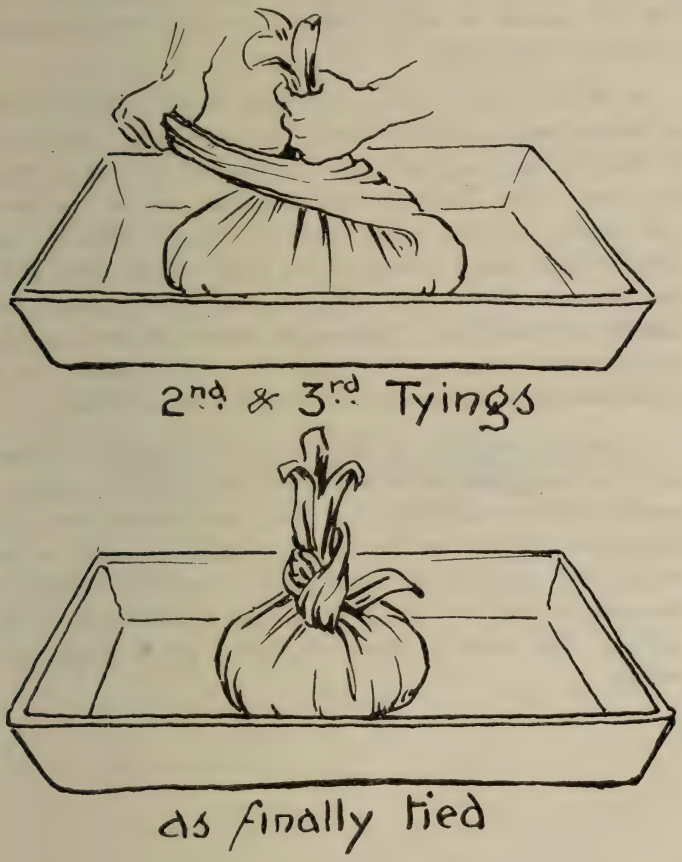


FIG. 13.

firming of the curd the bundle is tightened up considerably and turned over.

(*g*) After 20 minutes the matted curd is tied into 4-inch cubes, which are rearranged in the bundle and tied up tightly. This process is repeated until the curd is ready for milling.

(*h*) When the hot iron draws threads $\frac{1}{2}$ inch long, the curd is broken up by the hand into small pieces (milling).

(*i*) Salt is then added at the rate of 1 oz. to 4 lbs. curd. The salt should be evenly applied and the curd thoroughly stirred to incorporate the salt.

(*k*) After salting, the curd is filled evenly into the mould, which has been previously lined with a fine cloth. The follower is then put on, and light pressure applied by a small weight or stone. The cheese is turned at the end of two hours, and again put under light pressure. In the evening again turn out the cheese, wring out the cloth in hot water, return the cheese to the mould, and put under the pressure of a lightly-weighted lever. Reverse the cheese the next morning, and increase the pressure. Take out of the press at the end of 36 hours or two days, bandage, and cure as before.

In making this type of cheese, the main points to observe are that the drainage of the curd should be as complete as possible before moulding, and that the temperature is not allowed to fall too low during the making process, as often occurs with small quantities of curd. When this happens the drainage is slow and the curd remains soft and sloppy after milling. The resulting cheese is apt to go out of shape during curing.

SKIM-MILK CHEESE.

Synopsis (Skim-Milk Cheese).

1. Rennet the ripened milk at 84° F.
2. Cut the curd large.
3. Scald to 88° F. by heating the whey.
4. Draw the whey about 30 minutes after scalding.
5. Drain on the rack without pressure.
6. Mill when threads $\frac{1}{8}$ inch are got.
7. Salt and mould the curd.
8. Press and cure the cheese.

Skim-Milk Cheese.

Cheese made from separated milk alone is tough, leathery, and somewhat unpalatable, and its manufacture is not recommended. Skim milk produces a more acceptable article: the richer the skim milk, the softer the cured cheese. If separated milk is to be utilised, it should be mixed with new whole milk in the proportion of 1 part new milk to every 2 parts separated milk. Skim milk and whole milk may be mixed in the proportion of 3 to 1. Such admixtures will contain on an average 1 per cent. to 1·3 per cent. fat. Generally speaking, any milk containing less than 1 per cent. fat is too poor for cheese-making.

It is desirable that the separated or skim milk should have a clean flavour, and be as fresh as possible when the making process begins. Milk with a sour taste or smell is quite unsuitable.

The mixed milk is brought to a temperature of 84° F., usually by heating a portion of the milk itself and returning it to the making vessel.

Starter at the rate of 1 oz. per gallon is added, and the milk ripened for 1 hour.

At the end of this time the milk is renneted at the rate of 1 drachm to 2 gallons milk, the renneting temperature being 84° F., and the rennet being diluted with cold water before being stirred into the milk.

When the milk has coagulated it is cut vertically into squares with the knife, and reduced to $\frac{3}{4}$-inch cubes with the skimming dish or with the horizontal knife. The curd should be cut evenly, but too fine cutting should be avoided.

After cutting, the curd is stirred for 5 minutes and then settled for 5 minutes. A portion of the whey, equal to about one-fourth of the contents of the tub, is removed, heated to 100° F., and then returned to the vat. The aim is to raise the temperature to 88° F., which is the maximum temperature of scald.

After scalding, stirring is continued for 10 minutes, and the curd then settled in the whey.

After lying in the whey for 30 minutes, the curd will have firmed up, become somewhat springy, and will have acquired a bright appearance. On account of its increased density, the curd will now sink rapidly in the whey. The whey is then removed and the curd turned out on the rack. It is stirred for 1 minute to free it from whey, brought together in an even layer, and covered up with a dry cloth. After 20 minutes, when the curd has matted into a solid block, it is cut into 4-inch cubes, rearranged on the rack and again covered up.

About 40 minutes after the running of the whey the curd will have developed a flaky appearance. When it draws $\frac{1}{8}$ inch to $\frac{1}{4}$ inch on the hot iron, the curd is broken into pieces by the hand, salt is added at the rate of 1 oz. to $3\frac{1}{2}$ lbs., and the curd moulded and pressed as before. Pressure should be continued for 36 hours. The cheese is then bandaged and cured in the usual way. It will be ready for consumption in 3 - 5 weeks. In quality skim-milk cheese is much inferior to small-holder's cheese. It usually becomes hard after 3 - 4 weeks, especially when the milk used is poor in fat. Varieties of skim-milk cheese are used on the Continent for making soup.

COTTAGE CHEESE.

Synopsis (Cottage Cheese).

1. Pasteurise the skim or separated milk.
2. Ripen 18-24 hours with a good starter.
3. Cut and ladle the curd into a draining cloth.
4. Drain till the desired consistency is obtained (about 6 hours).
5. Add the salt (1 oz. to 5 lbs.)
6. Mix with a little well soured cream (1 lb. cream to 5 lbs. curd).

Cottage Cheese.

Cottage cheese may be made either from skim or separated milk which has been ripened with a starter, or it may be made from buttermilk. In either case, the process of manufacture is simple, and with a little care a palatable and nutritious article can be produced. Cottage cheese is consumed fresh; no ripening process is necessary. When well made, it keeps in good condition and retains its flavour for 5 to 8 days.

(1) Fresh skim or separated milk is first pasteurised by heating it to a temperature of 150° F., holding at that for 5 minutes, and then cooling back to 90° F. This preliminary treatment of the milk purifies it and enhances the keeping qualities of the finished cheese. Pasteurisation is essential if some considerable time has elapsed since the milk was produced. Cottage cheese made from old unpasteurised milk possesses a poor flavour, and quickly "goes off."

Starter at the rate of from 3 to 5 per cent. is added to the pasteurised milk at a temperature of 90° F., and the milk allowed to ripen in a warm place until it has coagulated firmly and the curd can be split clean under the finger. This usually takes 24 hours.

The curd is cut vertically into 1-inch squares with the long knife, and then turned over in successive slices with the skimming dish.

After cutting, the curd is heated to a temperature of 90° F. This facilitates the separation of the curd from the whey, and results in a quicker drainage.

The curd is allowed to settle for 10 minutes, and the bulk of the whey poured off or baled off. It is then transferred to a straining cloth spread over a draining rack or placed on the bed of a butter-worker, and allowed to drain. The ends of the cloth are brought together and tightened as the curd becomes drier and firmer.

Drainage is usually completed in from 4 to 6 hours. The curd should now have a smooth texture, and should hold sufficient moisture to enable it to cohere when made into a mould.

Salt is then added at the rate of 1 oz. to 5 lbs., and thoroughly mixed in.

Ripened (soured) cream, at the rate of 1 lb. to every 5 lbs. curd, added to the cheese just after salting, greatly enhances the quality of the cheese and improves its texture and palatability. The cream should be spread evenly over the curd and worked in by the hand. The curd is then spread out on an even layer about 2 inches deep, covered with a cloth, and pressed lightly with a weighted board. In 3 hours the cheese can be cut into squares and made up into packages if so desired.

(2) The process of making cottage cheese may be shortened by adding 1 drop of rennet to the milk at the time of adding the starter. The coagulum will be firm enough in 12 hours to permit of it being cut. After cutting, the curd is immediately drained, no heating, as a rule, being necessary. The other details of the process are the same as above.

(3) Buttermilk may also be employed in making cottage cheese if it is fresh and possesses a clean acid taste.

The buttermilk is heated to a temperature of 140° F., and held at that for 15 minutes. During this time it is kept continually stirred. It is then cooled to 90° F., settled for 20 minutes, and the bulk of the whey run off. The curd, which remains behind, is drained and salted as before. Drainage is usually slower than in the preceding case, but is facilitated by occasionally lifting up the sides of the straining cloth. The curd so prepared has a fine grain, and when mixed with a small quantity of freshly-soured cream produces a cheese with a nice smooth texture and a desirable flavour.

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THE MANUFACTURE OF CHEDDAR CHEESE.

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THE MANUFACTURE OF CHEDDAR CHEESE.

Preliminary Considerations.

The first and perhaps the most essential condition for the successful manufacture of high-grade Cheddar cheese is the use of pure, clean, sound milk. Makers of first-class Cheddars have long recognised this fact, but it is doubtful whether even yet the general body of cheesemakers sufficiently realise how much the flavour and keeping qualities of the cheese depend on the initial purity of the milk. Indeed, one of the methods by which the average quality of cheese made on the farm can be most rapidly improved is by strict observance on the part of the dairyman of scrupulous cleanliness in the production and handling of the cheese milk. Pure milk is even more necessary for cheesemaking than for buttermaking; in the latter case the milk may be purified by pasteurisation, but in cheesemaking the use of pasteurised milk introduces several difficulties into the process of manufacture, so that its general adoption is improbable.

The cows should be healthy, free from hereditary and contagious diseases, and above all, should have sound udders. The milk of cows suffering from any infection of the udder, such as mastitis, tuberculosis, or cow-pox, should not be used for cheesemaking. The milk of even one cow affected with chronic weed is often sufficient to contaminate a whole batch of milk, to introduce unexpected difficulties in the process of manufacture, and to render the production of a high-grade article impossible. Such milk may appear to be quite normal at the time of milking; its unsoundness can only be detected by the "fermentation test." This is a real source of faulty cheese.

Milk which is in any way abnormal should be avoided. The presence of even a small quantity of colostrum in the cheese milk is inimical; the curd is soft at cutting, and will not firm properly; the cheese during curing does not ripen normally, and sometimes putrefies. The milk of farrow cows, or of cows far gone in the lactation, as well as the milk of sick or fevered cows, should not be used. It is also better to withhold from the cheese vat the milk of cows in sexual heat. Cheesemaking will reveal any abnormality in the milk more surely than any other known test.

The milk should be produced under the best possible hygienic conditions. The byre should be well ventilated, but not draughty. It should be easy to clean, well lighted by suitable roof lights, and periodically disinfected. The standing space for the cows should be sufficiently long to obviate the necessity of the larger-sized cows standing with their hind legs in the gutter. The gutter should be sufficiently wide and sloped so as to carry off all liquids. There should be no inside traps or drains. Manure should be removed twice a day.

The feeding of bulky foods, like hay and straw, just before milking should be avoided, as these foods, when carried through the byre, make the air dusty, and thereby enormously increase the number of germs that find their way into the milk pail. Any food given before milking should be in the form of cake meal or other concentrated food. Foods which tend to taint the milk have an unfavourable effect on the quality of the cheese. All fermented foods, or foods which are partly decomposed, should not be employed. Turnips fed before milking, or given in excess, tend to produce a turnipy-flavoured milk, the more so if they have young growths on their crowns. In a cheesemaking dairy especially, only sound palatable foods should be given to the cows.

The cows, when housed indoors, should be groomed daily. Just prior to milking, the udder and flank of the cow should be wiped with a damp cloth. The first few streams of milk are highly contaminated, and should be rejected. The milkers should be provided with clean overalls, and should wash their

hands before milking each cow. Milking should be done with dry hands. The use of protected or hooded milk pails is strongly recommended, as thereby the initial contamination of the milk is reduced by nearly 60 per cent. Immediately after being withdrawn from the cow, the milk should be taken to the dairy and strained, preferably through an absorbent cotton filter. It should not, as is often the custom, be left standing for a considerable time in an open collecting vessel in the byre, otherwise the risk of contamination is greatly increased. All utensils coming into contact with the milk should be kept scrupulously clean.

Attention to these points—the health of the cow, the hygienic condition of the byre, the wiping of the udders prior to milking, the washing of the hands before milking each cow, the use of special milk pails, and the immediate removal of the milk to the dairy, are factors of real importance in cheese-making, and neglect of any of them cannot fail to lower the quality of the produce.

PROCESS OF MANUFACTURE.

Treatment of Evening and Morning Milk.

The evening's milk, after being run into the vat, should be promptly cooled by stirring it and by circulating cold water in the jacket. In summer this operation generally takes about 30 minutes. The temperature to which the milk should be cooled varies from 72° to 76° F., depending on season and weather conditions. In hot, fiery weather the temperature of the milk may require to be reduced to 70° F. or still further; the usual method where water is plentiful is to leave it running in the jacket overnight. In early spring and late autumn, when the temperature of the milk falls quickly, it should be stirred but not water-cooled. In the morning the temperature of the vat will vary from 60° to 65° F. as a general rule. The whole object in the cooling of the evening milk is to rid it of any "animal" odour and to bring it to such a temperature as will favour the slow development of the desirable lactic bacteria which are invariably present in milk that has been properly handled.

Within recent years some experienced makers of Cheddar cheese have adopted the practice of adding a few drops of starter to the evening milk. A better body and texture often result, and this procedure can confidently be recommended in cases where the cheese has shown a consistent tendency to be slow, or where abnormal fermentations are giving trouble during the making process. Great care, however, requires to be exercised. Only a few drops should be added to the vat, otherwise a fast cheese will result, and the texture of the cured product will be seriously affected. When starter is added in the evening, less than the usual amount will be required for the mixed milk in the morning.

The first duty of the cheesemaker in the morning is to take the temperature of the evening's milk. This furnishes a key to the development of acid overnight and the quantity of starter to be added. Whenever the temperature is 65° F. or over, less starter should be added and the rise of acidity during the ripening process carefully watched.

The cream is skimmed off and returned to the vat through a straining cloth. The object of this is to ensure the thorough distribution of the fat (which has separated out overnight) throughout the bulk of the milk. The cream, before being strained into the vat, may be heated up to 90° F.; this procedure, by rendering the cream more fluid, permits of it being more easily mixed with the milk. As a rule the heating of the cream, where only a comparatively small volume of milk is being handled, is not necessary, especially during the summer months, but where the cream layer is very thick, and also where larger volumes of milk (over 100 gallons) are being manipulated, it is advantageous to heat the cream.

The cold water in the jacket of the vat is then run off, and some hot water added in its place. Usually the temperature of the vat is raised to about 80° F. before the addition of the morning milk.

Adding the Starter.

The starter is now added. Some makers add the starter to the cream before returning it to the vat; if the cream has

been heated, care should be taken to see that its temperature is not over 100° F., otherwise the added starter may be injured. The quantity of starter used will depend on the season of the year, the type of cheese made (whether quick or slow ripening), and generally on the nature of the milk employed. Broadly speaking, the amount varies from $\frac{1}{4}$ per cent. to 1 per cent., the average being $\frac{1}{2}$ per cent., *i.e.*, 1 lb. to 20 gallons milk. Spring milk usually demands about 1 per cent. starter, summer milk $\frac{1}{4}$ per cent. to $\frac{1}{2}$ per cent., and late autumn milk $\frac{1}{2}$ per cent. to $\frac{3}{4}$ per cent. The general rule to follow is to add the smallest quantity of starter that will give a normally working cheese; that is, one in which the making process occupies about 7-8 hours. Considerable guidance will be got from the record of the previous day's cheese. It is better, as a general rule, to add an under-quantity rather than an over-quantity of starter. In the former case the main result will be that the making process will be prolonged, but if the curd is properly handled quite a good body and texture will result. In the latter case the time of making will be short. The rate of acid formation in the curd will be too rapid. The result will be that the cured cheese will have a dry body and a short, brittle texture.

Management of Starter.—The purity and vigour of the starter are factors of supreme importance. The vigour of the starter not only regulates the rate of acid production in the curd, and thus governs the time of making, but the more vigorous the starter the more completely will any abnormal fermentations in the cheese milk be controlled or suppressed. On the purity of the starter will depend very largely the flavour of the cured cheese. An impure starter, no matter how vigorous, cannot produce the fine flavour which so greatly enhances the food value of Cheddar cheese. The tendency hitherto has been for the practical cheesemaker to look on the starter as an agent to assist him in shortening the process of manufacture: he has not yet sufficiently realised that it is the starter which almost wholly controls the flavour of the finished article.

Starter may be propagated from the dry powder which is

sold as a trade article in hermetically sealed bottles, but as it requires special methods to prepare it for use it is better for the dairyman to purchase starter in the liquid form from a Dairy Institute. A 4-oz. bottle of such starter can be purchased for 1s. 6d.

It is important that the starter be propagated daily into freshly pasteurised milk, that it be ripened at a temperature of 65° F. to 70° F., and that it be in a softly coagulated condition when ready for use. The vessel (generally an enamelled pail) in which it is kept should be thoroughly sterilised before use, and during ripening should be kept covered with a clean muslin cloth. Starter should be kept away from direct sunlight. It should not be allowed to become over-ripe; excess of acid production greatly weakens its power, and if constantly allowed to become over-ripe, starter soon loses its vigour and is more liable to contamination by injurious yeasts and bacteria. If on any occasion the starter has thickened some considerable time before it is required, it should be immediately cooled down to a low temperature and additioned with some freshly-pasteurised milk. Another method is to add some sterilised chalk. A good starter should have a pleasant clean acid taste, and should ripen in from 6 to 8 hours. Whenever the starter loses its vigour or becomes gassy or acquires a bitter taste, however slight, it should be immediately discarded. It is bad policy to continue a starter simply because it is vigorous. If it has not the other necessary quality—purity—it should be rejected.

Ripening the Milk.

After the addition of the starter the morning's milk is run in and the contents of the vat raised to the temperature of renneting (84° F.) by the use of the steam-pipe connection or the addition of hot water to the jacket. The milk is now left to ripen, an occasional stirring being given to equalise the temperature and prevent the cream rising. The length of time the milk is allowed to ripen is dependent on several factors—the amount of acid formation in the evening milk, the kind and vigour of the starter, the quality of the milk, and the

type of cheese desired. As a rule the average time is two hours from the addition of the starter, or about an hour from the time the last morning milk was added.

If the cheese is to be coloured, the colouring matter—annatto—is added during the ripening period, generally about 10 minutes before renneting, and thoroughly stirred in. The average amount added is 2 oz. per 100 gallons. The colour may be diluted with 5 or 6 times its volume of water, to ensure its thorough distribution throughout the milk.

As soon as the milk is judged to be ripe enough, the rennet is added. Some makers estimate the degree of ripeness by the sense of smell; a few rely on the gift of imagination. There are two tests, however, for ascertaining when the milk should be renneted. That most commonly employed by cheesemakers is the "rennet test." To carry out this test, 4 oz. milk at 86° F. (taken from the vat) are added to 1 dr. rennet, contained in a cup or other suitable vessel, and the contents vigorously stirred with a teaspoon for 5 seconds. The forefinger is then inserted about the 15th second, and repeatedly raised and lowered until the first signs of coagulation are observed. The number of seconds that elapse between the addition of the rennet and the first appearance of coagulation gives the rennet test. The important points to observe are: the temperature of the milk must be at exactly 86° F. when the rennet is added: the rennet must be accurately measured and the seconds carefully counted. A stop-watch is very handy for this purpose. Some considerable practice is required to obtain proficiency in this test. For new milk the rennet test is usually about 24 to 25 seconds; in milk ready for renneting the rennet test should be approximately 20 to 21 seconds. It may be remarked that the rennet test is dependent on the strength of the rennet as well as on the acidity of the milk.

The "acidimeter test," in skilful hands, is quite reliable, and is largely employed in the colonies, in America, and in factories. It should, whenever possible, be used as a confirmatory test. The acidimeter is a graduated tube—or burette—containing a solution of caustic soda of definite strength. This is allowed to drop, with constant stirring,

into a measured quantity of the milk (1 oz.) or whey containing 2 to 3 drops of an indicator—phenol phthalein. The caustic soda neutralises the acid in the milk. The process is complete as soon as a permanent pink colour is apparent. An acidimeter reading should be taken as soon as the morning milk is added to that of the evening.

Usually the milk is ready for renneting when the acidimeter records a rise of ·02 over that obtained on the addition of the morning milk. If, for example, the acidimeter test of the mixed milk is ·20 per cent., then the rennet may be added when the acidimeter records ·22 per cent.

Renneting.

The milk having been allowed to attain the proper degree of acidity, the rennet is added. The quantity of rennet required when a standard commercial brand is used is on an average 1 oz. to 20 gallons; but milk produced on sour soils or on peaty pastures may require a higher renneting, while limestone soils demand a little less than the normal quantity. More rennet is required for autumn milk; less for spring milk.

The rennet extract should be pure, of uniform strength, and be possessed of good keeping properties. When rennet becomes turbid or has acquired a bad smell, it has begun to decompose, and should be discarded. As a rule, home-made rennet, prepared in the ordinary way, is too variable in strength, and has poor keeping properties. It should not generally be used when commercial rennet of standard strength can be had at a reasonable price. Being weak, home-made rennet gives a slow coagulation and a soft curd, and cannot be used with any degree of precision in making the rennet test.

If the rennet be added too soon, the time of coagulation will be prolonged and the cheese will be slow: if it be added too late, considerable amounts of acid will have been formed in the milk, with the result that the coagulation will be short and the cheese will work too quickly. It is better as a general rule to add the rennet early than to add it late. English Cheddars are renneted sooner than Scotch Cheddars. When a

soft meaty texture is desired, the ripening period should be a little shorter than normal.

The rennet is diluted with 5 to 6 times its volume of pure cold water, poured evenly over the surface of the milk, and thoroughly stirred in. If the milk has been renneted somewhat sweet, the period of coagulation is likely to be slow (about 1 hour), and the milk may require to be stirred for 10 minutes to prevent the cream rising, but if, as in Scotch Cheddars, the period of coagulation is comparatively short, stirring for 5 minutes will be ample. The vat is then covered up with a clean white cloth until coagulation is complete. The period of coagulation is on an average about 40 minutes.

Cutting the Curd.

As soon as the coagulum is firm enough, it is cut with the American knives. The curd is ready for cutting when it splits with a clean fracture under strain, or comes away clean from the side of the vat when the back of the hand is pressed on the curd surface. The curd is cut first with the vertical knife, lengthwise and crosswise; then with the horizontal knife in the same manner. If the curd is soft at the first cutting, allow a 5-minute interval to elapse before using the horizontal knife. In cutting, hold knives perpendicularly; avoid jarring or smashing the curd at the end of each stroke, and also overlapping the previous cutting. If the operation has been properly done the little cubes will be of uniform size, and the whey will be of a desirable green colour. But if the curd is cut too soon (while it is still soft), or if it is roughly handled, there will be a considerable loss of fat in the whey, which will consequently be white in colour. The fat content in whey should not exceed 0·3 per cent.; with careful treatment this may be reduced to 0·2 per cent.

As soon as cutting is completed, an acidimeter reading of the whey should be taken. Generally the reading is about ·13-·14 per cent.; if much higher than this—say ·16 per cent.—the cheese is likely to be fast, and consequently the curd requires careful supervision during the scalding process, and especially after it has been settled in the whey.

After cutting, the curd is stirred with the hand until it is firm enough to allow of the rake being freely employed. Hand stirring usually occupies about 10 minutes.

Scalding or Cooking the Curd.

The scalding or cooking process now begins. This simply means that the curd at this stage is slowly heated to a temperature several degrees above that of renneting; it does not imply that the curd is cooked or scalded in the ordinary sense of these terms. The object of scalding is to firm the curd and to assist in expelling the "moisture" simultaneously. The rate at which the curd is heated and the maximum temperature of scald are both important points. In Cheddar cheese making, the aim of the maker is to reach the maximum temperature within an hour after the curd is cut; the temperature should therefore be raised 1 degree in every 3 to 4 minutes. Below 90° F. the moisture is more slowly expelled than above 90° F., therefore heat slowly at first. The maximum temperature of scald for Scotch Cheddars varies from 98° to 101° F. English Cheddars are often scalded only to 96° F., a temperature of scald which may safely be adopted for summer cheese if the starter is pure and vigorous. Autumn-made cheese are usually scalded to 101° F., spring cheese to 98° F. Some milks require a higher scald than others to secure the same degree of firmness.

The effect of the scald is to form a film over the curd particles. If this film forms too quickly or becomes too thick, as a result of too rapid heating, the moisture becomes locked up in the curd. It follows that the curd will subsequently develop too much acid, and will frequently shed a white whey after milling and from the press.

Throughout the scalding process the curd is kept continually stirred. Raking, which begins slowly at first, must be conducted more vigorously towards the end of the "cook," as, on account of increasing density, the particles tend to settle more quickly to the bottom of the vat. During this time the curd should not be allowed to collect in the corners of the vat,

or to roll up into little balls. Stirring is continued until the curd is firm enough to be settled or pitched.

Settling or Pitching the Curd.

As soon as the particles have become firm enough, the curd is pitched or settled in the whey. The degree of firmness is estimated by the "feel": when a handful of curd is compressed, it should show little tendency to cohere. The acidimeter test at this stage is normally ·15 per cent. to ·16 per cent. If much higher than this, the acidity is coming on quickly, and the curd requires careful attention from now until the whey is run. The curd is allowed to lie in the bottom of the vat "cooking" in the warm whey until the requisite degree of acidity has developed. Usually the curd should be down about 1 hour. If much longer than this, the cheese is said to be slow.

Running the Whey.

This is usually regarded as the most critical step in the whole process. If the whey is run too soon, that is to say, before the curd has developed the proper degree of acidity, the curd will subsequently retain too much moisture, and the cheese on curing will be likely to go sour, more especially if the starter is not quite pure. The texture will tend to be soft and pasty, and the cheese may go out of shape in the curing room. On the other hand, if the whey be run off too late, the texture will tend to be short and brittle, though the flavour may be quite fair.

To determine the time for running the whey, Cheddar cheese makers almost invariably rely on the "hot-iron test." The testing iron is simply a flat bar of mild steel, about 18 inches long and 1 inch broad, fitted with a wooden handle. A portion of the curd from the vat is firmly pressed in the hand, to expel the whey, applied to the iron (which has previously been heated to a dull black heat) until it adheres, and then gently withdrawn. If a certain degree of acidity has developed, the curd will draw into threads. The length and

nature of these threads corresponds closely to the acidity of the curd.

The whey is run when fine silky threads, $\frac{1}{8}$ inch to $\frac{1}{4}$ inch long, are observed. If the threads are shorter than this, or are very thick, then the curd is still too sweet, and must be allowed to lie in the whey for a further period until acid enough. In applying this test it is important that the testing iron be at the proper temperature. To ensure this the iron is heated in the fire until it becomes red. It is then allowed to cool until the redness has disappeared; when held about an inch from the cheek the iron should give off a comfortable radiant glow. If the iron be too hot, the cheese will be toasted and the threads burnt off. On the other hand, if the iron be too cold the curd will not adhere properly and will fail to draw threads.

The acidimeter reading at the running of the whey is, for Scotch Cheddars, from ·23 per cent. to ·25 per cent., and should always be taken to confirm the hot-iron test. In certain circumstances the acidimeter is the only reliable test that can be applied at this stage, as, for example, if the cheese milk becomes stringy.

At this stage the curd will have contracted from the side of the vat by about the breadth of the fingers.

Some makers run off part of the whey in advance, especially when the cheese is slow, under the impression that this brings on the acidity. As a matter of fact, this has no material effect on the development of acidity. But in factories, or wherever large vats are used, it is an advantage to run off some of the whey in advance, especially if the acidity is coming on quickly. This practice is always adopted with a fast cheese.

Turning out the Curd on to the Rack.

On running the whey, the curd is scooped out on to the rack. Usually this is done as soon as the whey has fallen to the level of the curd. It is always advisable to keep the curd just covered by the whey at this stage, especially when large volumes are being handled and when the acid formation is

rapid; if this is not done the curd will mat quickly as soon as it is exposed to the air.

As soon as it is racked, the curd is stirred with the fingers, to free it from excess of whey. This operation usually occupies from 5 to 8 minutes, but the amount of stirring will vary with the condition and dryness of the curd. Prolonged stirring should be avoided, especially where a soft texture is desired. Stir "until the curd squeaks between the teeth."

Cheddaring the Curd.

When stirring is completed, the curd is brought to one end of the rack and spread out in an even layer of uniform depth (4 to 6 inches). It is then covered with warm, dry cloths, to maintain the temperature. Within 20 to 30 minutes the particles will have united into a solid mass. The matted curd is then cut up into blocks about 10 inches square, turned right over, and again covered up. After the lapse of 20 minutes the curd blocks are piled up on one another two deep. At the same time the blocks are rearranged as regards position: the central blocks are removed to the outside, and the outer blocks brought to the centre of the rack. This is done to equalise the temperature and maintain an even development of acid throughout the curd. The process of piling and rearranging the blocks is repeated every half hour until ready for milling. Care should be taken to keep the curd well covered up, and not to allow the upper surfaces to become exposed to the air or to become chilled.

As a result of this cheddaring process, the curd develops a marked leafy or foliated texture: "it tears like meat on the breast of a chicken."

During cheddaring, acidimeter readings should be taken and tests with the hot iron made from time to time, in order to determine the progress of acid development.

The usual cheddaring temperature is from 92° F. to 95° F., or about 4 to 6 degrees below the maximum temperature of scald. The time occupied by the cheddaring process is usually about 1½ hours, but it varies according to the development of acidity and texture of the curd mass.

Draining in the Vat.—Instead of turning the curd out on the rack and cheddaring it there, the curd may be drained in the vat. This is often done with Dunlop cheese, and with English Cheddars made after the Cannon system. The merit claimed for this method is that it gives the ideal soft meaty texture so much in demand by some cheese factors. The whey is run off completely and the curd pushed to one end of the vat. A channel is cut down the centre; a strip of about 2 inches wide is removed, broken up, and spread over the curd layer on either side. The curd is covered up and allowed to mat in the bottom of the vat. As soon as matted, it is cut into square blocks and turned over on its back. At the end of 20 minutes the blocks are cut up into 4-inch cubes and tied up in bundles of, approximately, 56 lbs. each, and weighted 28 lbs. to each bundle. The bundles are opened up, the matted cubes torn apart and rearranged, and the bundles retied and reweighted every 30 minutes until the curd is ready for milling. Instead of bundling the curd, the blocks may simply be piled two deep and covered with a cloth; a wooden rack, on which are placed weights, is then put on the top. The blocks are opened up, rearranged, and reweighted. By either of these methods a curd possessing a fine leafy texture at milling is obtained.

Milling the Curd.

The curd may be milled when the hot-iron test shows fine silky threads about $1\frac{1}{4}$ inches long, or when the acidimeter records ·75 per cent. to ·80 per cent. acidity. At this stage the curd should have developed a marked foliated texture; it has lost all trace of harshness, and is smooth and mellow; it tears easily in thin strips.

The object of milling is to rend the curd into pieces (not too small), and to bring it to a fit state for salting. The mill should not be too closely set. The curd, after milling, is weighed and then stirred on the cooler to aerate it and to cool it to a temperature of about 80° F. to 82° F. The curd, after stirring, is brought together and allowed to lie until ready for salting.

Salting the Curd.

The hot-iron test is now $1\frac{1}{2}$ inches to $1\frac{3}{4}$ inches. The threads are very fine and silky, and when broken fly back on the iron; the curd, when applied to the iron, smells like toasted cheese. The temperature, when the salt is added, is usually 78° F. to 80° F. The rate of salting for Cheddars is 1 lb. to every 50 lbs curd, but for a quick-ripening cheese rather less is added. The salt should be sprinkled evenly over the curd, and the curd well stirred for 5 to 10 minutes. The salt must be pure, readily soluble, and sharp in the grain. A very fine salt does not permeate the curd so thoroughly as one which is sharp in the grain. An interval of 15 to 20 minutes should be allowed for the curd to absorb the salt before the next stage —hooping. The addition of the salt cools the curd so that the temperature falls several degrees.

Hooping the Curd.

The important points in moulding or hooping are that the curd should be at the proper temperature and that it should be evenly filled into the hoop and consolidated in layers by hand pressure. The standard temperature for chessiting is 76° F.; a higher temperature than this in summer usually results in a considerable loss of fat from the press. On the other hand, if the curd be hooped too cold, the particles do not unite properly under pressure, and the cured cheese may exhibit numerous ragged holes. A higher temperature of hooping—78° F. to 79° F.—is employed in early spring. Previous to the filling in of the curd, the hoop should be lined with a clean cheese-cloth. The curd should be packed well in the centre, otherwise the air and the whey, during subsequent pressure, will become locked up in the centre of the cheese. Finally, when the hoop is filled, the ends of the cloth are brought over the curd, the follower put on, and the chessit taken to the press.

Pressing the Curd.

The object of pressing is to give shape, to press out any remaining whey, and to form a crust or rind. The pressure

should be gradually and evenly applied: the screw of the press is brought to bear on the follower of the chessit and given a few turns—just sufficient to start the whey running freely. 10 to 15 minutes later the full pressure of the screw is applied (5 to 8 cwts.). At the end of 30 minutes the pressure is increased by the addition of one or two weights to the lever arm of the press. At the end of 1½ hours a pressure of 20 cwts. should be reached. The best way to secure a regularly increasing pressure is to add the discs at regular intervals, *e.g.*, two every half-hour. Unless the pressure is gradually applied in this way, the crust will form too rapidly, and excess of whey will remain in the curd. The result will be that the cheese, during curing, will become over-acid or sour, and may leak whey in the curing room, especially during hot summer weather.

The acidity of the whey from the press is usually ·95 per cent., but it may vary from ·9 to 1·0 per cent.

The amount of whey draining from the press depends on the moisture content and on the acidity of the curd. For Cheddars this should not generally exceed 4 lbs. per 100 lbs. curd. The fat percentage of the press whey should not, as a rule, be much above 3 per cent. A higher fat content argues either too high a temperature of the curd at pressing or the retention of too much moisture in the curd in the earlier stages.

The temperature of the press room should be about 70° F.

Subsequent Management of the Cheese during Pressing.

Pressure should be continued for three days. The following method of procedure gives a well-finished cheese:—

Day of Making.—About 3 hours after being put to the press, the cheese is taken out of the hoop and the edges trimmed. It is reversed in position, returned to the chessit in the same cloth (wrung out in hot water), and put to the press under a pressure of 25 cwts.

Second Day.—On the morning of the second day the cheese is taken out and bathed in hot water at 135° F. for

one minute, or at 140° F. for a few seconds. The object of bathing the cheese is to impart a fine rind and prevent too rapid evaporation during curing. It will be understood, of course, that the cheese is completely immersed in the warm water : the mere pouring of hot water over it is not sufficient. After bathing, the cheese is returned to the chessit in the same cloth, but no pressure is applied.

In the forenoon, or about 4 to 5 hours later, the cheese is again removed from the vat and a drying cloth put on. A pressure of 25 cwts. is now applied. The object of this is to dry the crust.

In the evening—about 6 hours after—the drying cloth is replaced by a fine smoothing cloth and the cheese returned to the press under the maximum pressure—30 cwts.

Third Day.—The cheese is taken out, greased with melted lard, caps put on the ends, and returned to the chessit in the smoothing cloth. Full pressure is again applied.

Fourth Day.—Finally the cheese is bandaged and sent to the curing room.

Curing the Cheese.

It has been well said that the cheese is only half made when taken to the curing room. The meaning of this dictum is that on the management of the cheese during curing will depend to a great extent the quality of the finished article. The curing room for preference should be situated upstairs; when located on the ground floor the room is inclined to be damp, and a satisfactory circulation is difficult to maintain, especially on languid summer days. The result is that the cheese is more liable to sweat, and mould growth is difficult to suppress.

The temperature of the curing room should be maintained between 55° F. and 60° F. At temperatures over 60° F., not only is the quality of the best cheese impaired, but there is an undue loss by evaporation and a resultant dryness of body.

The crust sometimes cracks, especially if the air be very dry and if the cheese be "full acid"; the evaporation from the interior of the cheese is thereby still further increased. At low temperatures cheese cures more slowly, but the quality remains good, and there is less shrinkage.

During cold weather the curing room requires to be heated. This is best effected by the use of hot water or steam pipes. An open fire or stove is less satisfactory.

The humidity of the curing room should receive careful attention. If the air of the curing room is too dry the rate of evaporation or shrinkage will be greatly increased, and the body of the cheese will become too hard and firm. On the other hand, if the air is too damp the intervention of mould growth is almost certain. An effort should be made to maintain at 80 per cent. of the saturation point (as measured by the wet and dry bulb thermometer).

While in the curing room, the cheese is turned daily for at least 8 weeks, and every second day thereafter until ready for sale. If this has to be done by the hand the work is very laborious. Most modern dairies are now fitted with turning dales, which renders the work both easy and rapidly done.

Cheese should not generally be sold until it is ripe. The marketing of half-cured cheese is detrimental both to the producer's interests and to the consumer's digestion. If the cheese be cured for at least three months both parties would reap the benefit.

Bulletin No. 89.

The West of Scotland Agricultural College.

REPORT

ON

EXPERIMENTS

ON THE

FEEDING VALUE OF BRACKEN RHIZOMES

FOR

PIGS AND POULTRY.

Glasgow:
Printed by Robert Anderson, 142 West Nile Street.
1919.

REPORT ON EXPERIMENTS ON THE FEEDING VALUE OF BRACKEN RHIZOMES FOR PIGS AND POULTRY.

Introductory.

Arising out of the unprecedented shortage of feeding-stuffs during last year attention was directed to the possibility of utilising bracken rhizomes or "roots" as a food for stock, and the experiments herein described were carried out at the suggestion of Professor Hendrick, Live Stock Section, Ministry of Food, by whom the bracken rhizome was supplied. An article on "The Composition and Food Value of Bracken Rhizomes," by Professor Hendrick, appeared in Vol. I, No. 4 of the *Scottish Journal of Agriculture* (October, 1918), and this report should be read in conjunction with that article. The experiment with pigs was carried out through the kindness of the Directors of the Scottish Co-operative Wholesale Society, by Mr. Geo. G. Young, Calderwood Estate, East Kilbride; that with poultry at the Poultry Department, Holmes Farm, Kilmarnock.

REPORT ON EXPERIMENT WITH PIGS

[By Mr. James Wyllie, B.Sc.]

On 17th June last two lots, each of six pigs, were carefully selected out of a large number of stores, weighed, and placed in two adjacent pens. The average live weight per head of Lot 1 was 96 lbs., and of Lot 2 92½ lbs. The treatment of the two lots was in every respect the same, except that Lot 1 received bracken rhizome along with the ordinary meals, while Lot 2 received meals only. Owing to the scarcity of the common pig meals, it was impossible to prescribe rations in advance, and no attempt was made to keep an accurate record of the total consumption of meals; but *the kinds and amounts of meals consumed by the two lots were exactly the same*, Lot 1 receiving bracken rhizome as an extra. This method of feeding was adopted to simplify the work as much as possible, but it resulted, of course, in Lot 2 being always slightly underfed.

During the first four weeks of the experiment Lot 1 consumed about 1 cwt. of the bracken rhizomes as dug, but air dried. The rhizomes were soaked in water for about 12 hours before feeding, and then thrown in to the pigs, which ate them greedily.

During the remainder of the experiment—16 weeks in all—the rhizome was fed in the form of a meal, at a rate rising from about 1 lb. up to 2 lbs. per pig per day, the total quantity consumed being 6 cwts. Part of this was fed separately as a mid-day meal, and the remainder was mixed with the ordinary meals. All the pigs ate the bracken meal with apparent relish, and so far as could be judged it had no bad effect upon the digestive organs or otherwise.

The following table shows the results of the successive weighings :—

Average Live Weight on	Lot 1. (Meals and Bracken Rhizome) Lbs.	Lot 2. (Meals only) Lbs.
June 17	96	$92\frac{1}{3}$
July 1	108	103
,, 15	$120\frac{1}{2}$	$112\frac{2}{3}$
,, 29	$126\frac{1}{3}$	$120\frac{2}{3}$
Aug. 12	$136\frac{1}{3}$	$126\frac{2}{3}$
,, 26	$141\frac{1}{2}$	$135\frac{2}{3}$
Sept. 9	$154\frac{1}{2}$	$143\frac{2}{3}$
,, 24	$160\frac{2}{3}$	$154\frac{2}{3}$
Oct. 7	$175\frac{1}{2}$	$167\frac{1}{2}$
,, 19	184	$175\frac{5}{6}$
Nov. 4	$203\frac{2}{3}$	$191\frac{2}{3}$

It will be seen that Lot 1 increased in live weight from 96 lbs. to $203\frac{2}{3}$ lbs. per head, or $107\frac{2}{3}$ lbs. in 140 days, *i.e.*, at the rate of 0·77 lb. per head per day, while for Lot 2 the total increase was $99\frac{1}{3}$ lbs. per head, or 0·71 lb. per head per day. In other words, the bracken-fed lot showed a gain of $8\frac{1}{3}$ lbs. per pig, or a total gain of 50 lbs. live weight over the lot receiving meals only.

This gain has resulted from the consumption of about 7 cwts. dried bracken rhizome, so that it has taken about $15\frac{1}{2}$ cwts. dried bracken rhizome to produce 1 cwt. increase in live weight.

Taking the price of pigs at 112s. per live cwt., the value of the bracken rhizome works out at about 7s. 3d. per cwt. when in the dried condition; with pigs at 56s. per live cwt. it would only be about 3s. 7d. per cwt.

The dried rhizome meal contained about 10 per cent. water, whereas the fresh rhizome (as dug) contains from 75 to 80 per cent. Hence, according to the above result, in order to produce 1 cwt. live weight increase it would require about 65 cwts. fresh rhizome—worth less than 2s. per cwt. with pigs at 112s. per live cwt., and less than 1s. per cwt. with pigs at 56s. per live cwt.

One pig in Lot 2 was somewhat "groggy" on its legs for several weeks towards the end of the test, and, although eating well, it was not putting on weight as it would otherwise have done. All the other pigs proved good doers, and the comparatively small increases in weight can only be accounted for by the restricted quantity and poor quality of the meals being fed. The bracken rhizome had no apparent effect on the health of the pigs, but it was noticed that those receiving bracken rhizome had a somewhat darker skin, while the hair was less glossy than where meals only were fed.

REPORT ON EXPERIMENT WITH LAYING HENS.

[By Miss Agnes Kinross.]

For this experiment, carried out from 1st October to 30th November, 1918, three pens of white Leghorn pullets were selected as equal as possible as regards maturity. Two pens contained ten birds each, and the third pen nine birds. All three pens were fed on the same grain, viz., oats, the total quantity for the day being 2 ozs. per bird. 1 oz. was given in the morning, and 1 oz. at noon. They were all fed on soft mash in the afternoon.

No. 1 pen (10 birds) received mash made with cooked brock, viz., vegetables, potatoes, &c., mixed with offals, bran and thirds, and bracken meal. To begin with, 8 ozs. of the latter was used; but this quantity had to be considerably reduced

before the birds would eat the mash. It was decreased to 1 oz., and, after about a week, was increased to 2 ozs. This quantity, along with 4 ozs. of offals, was used during the whole of November.

For No. 2 pen (10 birds), the soft mash consisted of cooked brock as for No. 1 pen, mixed with offals, dried grains, and a very little biscuit meal. There was no difficulty in getting the birds to eat as much of this mash as satisfied their appetite.

For No. 3 pen (9 birds), the mash consisted of cooked brock similar to the other two pens. It was mixed with offals, biscuit meal, oatmeal, and Indian meal. (A small quantity of these two meals had been held in reserve for a very long time.) The brock used in all three lots amounted to practically half of the mash given.

The return in eggs from the three pens was as follows :—

Pen No. 1—Total number of eggs for October and November, 103—total value, £2 7s. 2½d.

Pen No. 2—Total number of eggs for October and November, 143—total value, £3 5s. 6d.

Pen No. 3—Total number of eggs for October and November, 307—total value, £6 17s. 1½d.

The eggs averaged 5s. 6d. per dozen for both months.

At the beginning of the experiment the most matured birds were undoubtedly in Pens 1 and 3. Pen No. 2 was longer in starting to lay.

The birds were trap nested, and all of them were laying in Pen 1. In Pen 2 only 6 birds had started to lay during the two months. In Pen 3 all the birds had started during the period. The laying throughout the period in Pen 1 was very irregular. Every other day no eggs were laid.

It would therefore appear that, as a food for egg production, bracken meal is of low feeding value. If tested along with meals of better quality, or if used for fattening purposes, the results might be different.

The experiment is also of interest in that it shows the increased returns to be derived from feeding birds for egg production on good foods, and that it will pay to do so.

General Conclusions.

It is impossible to draw any definite conclusions as to the feeding value of bracken rhizome from such a limited experience, but it cannot be said that the above results are very encouraging. In the pig experiment it was considered that the bracken-fed lot was rather favoured, not only on account of the method of feeding, but also because one pig in Lot 2 proved to be only a middling doer, but the number of pigs under trial was too small to justify a definite statement being made either for or against bracken rhizome. Further experiments are also required with poultry, not only for egg production but also for fattening purposes.

Bulletin No. 90.

The West of Scotland Agricultural College.

CROPPING UNDER WAR CONDITIONS.

BY

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CROPPING UNDER WAR CONDITIONS.

AGRICULTURE is now very much in the lime-light, and the nation, after years of neglect, would seem at last to have realised the vital importance of the industry which in reality is the first, the greatest, and indeed in many respects the mother of all industries.

A nation not self-supporting as regards food and other necessaries of life is at a very great disadvantage in time of war. Britain is in that unfortunate position to-day, hence the necessity for increasing materially our home food supplies.

The country is not producing nearly all that it is capable of yielding, and even with the ranks of our agricultural workers sadly thinned as they were in the spring of this year, much more might be achieved.

We know to our cost that Germany prepared for war for years, but we often overlook the fact that her soundest line of preparation lay, not in the manufacture of powerful guns, the turning out of millions of shells, the building of submarines, nor yet in the training and equipping of her vast army, *but that it lay in developing her agriculture.* Her foresight and our appalling lack of foresight in that respect have greatly prolonged the deadly conflict.

The cry in this country was for cheap food. Cheap food was forthcoming, the major part of it from overseas, and those following the industry on which the very stability of the nation depended got little in the way of encouragement, and even less in the shape of assistance. All honour to the much-maligned British farmers who survived and actually progressed under such adverse conditions, for progress they certainly did; but how different the position to-day would have been if the agriculture of this country had been supported and developed, even during the last quarter of a century, as it ought to have been! Our little Island Home would have been much more

nearly self-supporting than it is as regards the prime necessaries of life.

To put the Motherland in a strong position in that respect is surely a worthy ideal and one well worth striving for, and though at present we are a very long way from being in such a secure state, the goal is not altogether unattainable, at least as regards most of life's necessaries, and to attain it should be our great endeavour.

If we are to come at all near that ideal we must have a sound agricultural policy, and the land must be made to produce all that knowledge, skill, and foresight can wrest from it; but this cannot be done in a day or even a year, and considerable time must elapse ere we can hope for such a happy consummation.

Cropping under War Conditions is a very comprehensive subject, and one which could not be fully dealt with unless in a lengthy treatise. It has therefore been thought best, in the scope of this paper, to direct attention to certain aspects of the subject which merit special consideration.

Considered in the light of the country's need at the moment, it is surely the duty of every farmer to see that the land he farms is made to produce—either directly or indirectly—the maximum amount of food for human consumption it is capable of yielding without entailing, unless in special cases, very radical changes in the method of stocking and working.

We must produce at home a much greater proportion of the food we consume, and the first question before us is the best method of doing so.

Essential Steps towards Increased Production.

Undoubtedly the first step towards this end is to make the very most of every acre of land already under the plough, since, viewed from every standpoint, this method of adding to our food supplies easily ranks first. The possibilities in this connection are much greater than is generally realised. The yields commonly recorded are a long way from what might be called maximum profitable production, and by a more general adoption of approved progressive methods, such as liberal but

judicious manuring, selection of heavy cropping varieties, &c., there is reason to believe that crop production in Scotland might easily be raised by as much as 20 per cent., or even 30 per cent., from the area at present under the plough. This method of increasing food supplies is a simple, straightforward one, and it brings in its train no troublesome complications.

When we are making the fullest use of the land already under the plough, the next step should be to increase the area under cultivation, but there would not be much sense in doing so if the land already under crop was only yielding two-thirds or three-quarters of what might be obtained from it. True, it would no doubt add to our food supplies, but it would not be the best method of doing so, as the increase would be obtained at much greater cost, and moreover this way would ultimately entail considerable modification in the method of farming.

It is to be feared that in the crusade for increased food production, so much stress was put on the need for increasing the area under crop that the fact was occasionally overlooked that, though very essential, acreage after all is only a means to an end. Food and not acres is the primary aim.

Further, in connection with increasing the area under the plough, there is need for very great discrimination as to the type of land to break up and the situation of same. Labour is scarce, supplies of manure are none too plentiful, and grain and potatoes are much too valuable for food purposes to warrant their use for seed, unless where there is every prospect of a reasonably good return. It behoves us therefore to concentrate, in the first place, on the good land, as that will give a surer and relatively better return for labour employed thereon, and for seed and manure applied thereto. In fact, apart altogether from the great saving in these respects, 100 acres under crop, of reasonably good land in a suitable locality, may, and often does, produce as much food as is obtained from 150 or even 200 acres of poorer land in a less favourable locality. The writer does not for a moment wish it to be inferred from this statement that he is not in favour of breaking up the poorer land, and such a conclusion would be entirely wrong, but he desires to *specially emphasise* the great need under war conditions for getting, in the first place, as large an area as possible

of really good land under crop. That constitutes the surest and much the most economical method of adding to our food supplies, and this aspect of matters does not always appear to have received the consideration it merits.

It is a fairly sound War Agricultural Policy to advocate, as far as it is feasible, ploughing up first the best, then the second best, and to reserve for grazing that which is not so good. It will be readily apparent to any one who has given the matter any thought that the greater the area under crop required to produce 100 tons of food, the greater demand there will be on labour, for seed, manure, &c.; hence the importance of concentrating on the best to begin with, in order to economise in these and other respects. You may get approximately the same amount of milk from a herd of dairy cows, without materially affecting the cost of production, though you have to allow them twice the former acreage of land to furnish sufficient pasture, but with land under the plough it is entirely different.

The taking of the best will necessarily entail the breaking up of many of our fine old pastures, and though one would naturally be a little sorry to see this done, it must be remembered that the better the land under pasture the more reason there is for putting the plough into it, as it will produce much more food for human consumption under crop than under grass, even though utilised for the grazing of dairy cows; indeed, its productive capacity is likely to be raised to at least three times what it was under grass, so that no reasonable argument can be advanced for keeping such land as has been referred to under pasture when the nation is threatened with a serious food shortage.

We must make the most of every acre under crop, we must add to the present acreage under the plough, and in doing so see that we bring into cultivation the best land obtainable, as these are essentials in any sound scheme of war-time cropping, which has as its main aim a large and immediate increase in production.

Different Crops.

When the requisite area of suitable land has been secured for the plough, the next point to consider is how best to apportion it to the different crops, and this is a more difficult problem, and one regarding which there is greater room for diversity of opinion.

The climate and soils of Scotland limit us in the range of crops we can successfully grow, but amongst those commonly grown there are some of much greater value for human food than others. In this respect the *Potato Crop* ranks exceptionally high, and its cultivation should be encouraged in every possible way. It is a valuable crop for rich old grass lands, where there would, in the first year after breaking up, be great risk of a cereal crop lodging; it is equally valuable in the usual rotation on average soils, while large crops can also be raised on very poor soils, provided the crop is liberally manured.

We are not likely to produce more potatoes than will be required for human consumption, but, even if we did, the surplus would prove invaluable for many purposes, including even the feeding of cattle, pigs, and poultry.

With regard to the actual food value of an average crop of potatoes, figures commonly put forward purporting to show the food value of certain crops, calculated on the basis of the total energy value in calories, show the number of days' food supply for man from one acre of potatoes—average crop, less seed—to be 1,289, or approximately equivalent to one man's requirements for a period of $3\frac{1}{2}$ years. This figure is probably much too high, as the writer firmly believes that, in arriving at it, insufficient allowance has been made for what might be called inevitable waste in the use of potatoes as human food. A deduction of roughly one-twelfth of the total calculated value has been made in arriving at the actual food value, but it is to be feared that, unless we change our methods of using potatoes, the deduction would be much more accurately represented by one-quarter than by one-twelfth. Even were the greater deduction to be made the potato crop would still remain an outstanding one from the point of view of value for human food, as no other root or grain crop commonly grown in Scotland is

equal to it in that respect when valued on the basis already referred to.

We were singularly fortunate as regards the potato crop last year, but there is no reason whatever why the exceptional yield of 7½ tons per acre obtained in Scotland should not become the average yield instead of that of slightly over 6 tons per acre commonly reported.

If the practice of sprouting potatoes previous to planting were more generally adopted by all growers, that alone would go far towards securing the desired result. Moreover, it would greatly lessen the risk of failure of the crop, as the benefits from sprouting previous to planting are generally greatest in adverse seasons. This was very clearly demonstrated in 1916, as in that year crops raised from sprouted seed did not suffer to anything like the same extent.

The average increase in yield which results from sprouting the seed previous to planting is certainly not less than 2 tons per acre, and with many varieties it is much more than that. Not only so, but as the increase generally consists almost entirely of "ware" or "firsts," the actual benefit is even greater than the increase in yield would appear to indicate. The fact that the crop is ready for lifting earlier is also not without importance, both under war conditions and in normal times.

Another factor materially affecting yield and meriting special importance in war time, when we are faced with a possible shortage of food, is the importance of selecting heavy-cropping varieties of potatoes, rather than poor-yielding ones famed for quality, as a hungry man is likely to think less about quality than quantity. It is not necessary to make any material sacrifice in that respect, as there are plenty well-known heavy-cropping varieties which are excellent keepers and of quite good quality. With all their merits the cultivation of varieties like Langworthy and Golden Wonder should not be encouraged at the present time, as they do not yield the tonnage desired per acre.

There are several other methods of increasing the yield of the potato crop, but if even the two methods briefly referred to were more generally adopted, and the crop at the same time

liberally and judiciously manured, the average yield per acre would be materially raised, and we would have as a result a most valuable and welcome addition to our food supplies.

We cannot get away from the fact that the potato crop is in some respects a risky one to grow, and from that and other points of view it has drawbacks as a war-time crop; but to-day there are a very large number of varieties from which to select, many of which have been proved immune from Wart disease, and as ordinary potato disease can to a very great extent be successfully combated by spraying, there is not the same risk of failure of this crop as formerly.

Sugar Beet.—The cultivation of Sugar Beet is receiving a certain amount of attention at the present time, due largely to scarcity of sugar. Dealt with on the same basis as the potato crop, the calculated food value per acre from an average crop is even higher than that from potatoes, but the two crops are totally different. They are grown for entirely different purposes, and the one could not replace the other.

Sugar Beet can be quite successfully grown in several districts in Scotland. That has already been conclusively proved. Where mangels succeed it is likely to succeed equally well, but it would be a mistake in policy to advocate its cultivation as a method of war-time cropping. The sugar has to be obtained from the beet by a special process of manufacture which calls for suitable buildings, plant, and labour. Not only so, but even when obtained sugar can only form a comparatively small part in a mixed diet, while potatoes may constitute a fairly large part.

It is quite true that sugar beet grown in several districts in the south-west of Scotland has been shown, both as regards yield per acre and sugar content, to compare not unfavourably with that grown on the Continent, so from that point of view there is no great difficulty; but, on the other hand, if we were to produce at home a fair proportion of the sugar we consume, we would require to put a very considerable acreage under sugar beet, and the setting aside of the necessary acreage for sugar beet, in place of the root crops commonly grown, would be likely to leave us short of potatoes and also to affect adversely the winter production of milk, beef, and mutton, as the residue

per acre available for stock-feeding, after the extraction of the sugar from the beet, though valuable, is far behind the value of the produce per acre from a like area under swedes, mangels, cabbages, or similar crops; and, after all, from the nature of the product it is much easier to import in war-time the necessary supplies of sugar than to import beef or mutton.

The root crops, other than potatoes, commonly grown are used chiefly for the feeding of live stock, and do not contribute in the same direct manner as that crop to our food supplies. Nevertheless these root crops assume very special importance in view of the great shortage of concentrated feeding-stuffs, as we must rely even more than formerly on *turnips*, *mangels*, &c., to aid in the winter production of milk, beef, and mutton. We have also to remember that with a larger area under grain crops we are likely to have much more straw to utilise, and when consumed as fodder the root crops already mentioned prove specially valuable for feeding along with it.

Grain Crops.

As regards the different grain crops commonly grown in Scotland there is little required in the way of comment, as much has been written from time to time, and since, after all, soil and climate in great measure determine the crop which should be grown.

Wheat is, of course, of relatively greater value for human food than *barley* or *oats;* indeed, in certain respects this crop is superior to potatoes, and in a scheme of war-time cropping should take precedence over that crop in spite of the rather lower calculated food value per acre already referred to. Oats certainly constitute the most important cereal crop of Scotland, since soil and climate of the country are much better adapted for the growth of that crop, but wheat should be given the preference whenever the conditions are such that the crop is likely to succeed. The relative positions of the three common cereal crops, calculated on the basis of energy value in calories, per hundred acres—average crop, less seed—and allowing for offals being fed to cattle, are as follows :—

100 acres wheat provides food for 230 persons for 1 year.
„ barley „ „ 180 „ „
„ oats „ „ 155 „ „

It will be seen that from the point of view of food value calculated on the basis referred to above, barley is intermediate between oats and wheat; but if as great a proportion of this grain has to be used for the same purpose as formerly, then the less barley and the more wheat and oats that are grown in Scotland the better and more suitable will be the system of cropping for war conditions and for normal conditions as well.

The yield of cereals might be very greatly increased, since, as in the case of the potato crop, we are a long way short of maximum profitable production, which should be our aim as regards yield.

Selection of good seed of high germinating capacity, treatment of seed for the prevention of such diseases as smut, and change of seed under certain conditions, may all contribute materially towards securing an increase in yield; but two steps calculated to bring about a very considerable increase in yield are undoubtedly (1) a more general and more liberal use of a well-balanced mixture of artificial manures, and (2) the selection of varieties noted for their grain-producing combined with their standing powers. By devoting a little more attention to these two methods of increasing yields, the production of cereals in Scotland might be very materially increased, and our dependence on oversea supplies proportionately reduced.

Of the other grain crops, *Beans* assume very special importance under the conditions in which we find ourselves placed to-day. The great majority of our home-grown foodstuffs are sadly deficient in digestible protein, and to make the fullest use of these foods we require to use them in conjunction with foods rich in protein, in a form which is both palatable and digestible. Bean meal provides a large amount of protein in the desired form, and thus—in view of the greatly reduced supply of concentrated feeding-stuffs—the bean crop proves very valuable, not only on account of the food it provides, but also because it enables us to utilise to much better advantage common farm foodstuffs, such as hay, straw, and roots. For these reasons the cultivation of this crop should be encouraged and an effort made to greatly increase home production, as an increased supply of home-grown beans would prove a potent factor in keeping up the winter milk supply.

Beans may be grown alone, or a crop of "mashlum" (beans and oats) may be taken, but in either case the crop is a very valuable one, as both bean meal and mashlum meal form particularly valuable foods for stock. Beans are, of course, a heavy-land crop, and it is on strong clay soils that the largest crops are raised, but certain varieties succeed well on medium soils, and mashlum can be successfully grown on any soil from a medium loam up to a heavy clay.

The area under beans in Scotland in 1917 was just slightly over 6,000 acres, and though this shows an increase over the previous year, it represents just a little more than one-quarter of the area under beans fifty years ago. The falling off in the acreage under this crop was brought about chiefly by the importation of large quantities of beans, which were put on the market at a price at which it was difficult to produce beans in this country, consequently much of the heavier land suitable for growing beans and wheat was put under grass.

As a method of war-time cropping, cultivation of beans merits, and indeed demands, special consideration.

Other War-Time Modifications in Cropping.

Modifications in cropping are not only desirable, but become absolutely necessary in a system of cropping under war conditions.

The usual rotation becomes upset as the area under the plough is increased, and time is required to adjust it to the altered conditions.

Avel Cropping.—By another spring, and following the usual order of cropping, the area available for root crops will be very much above the normal. Most root crops entail a very great deal of labour, both "horse" and "manual," and since those commonly grown in Scotland, with the exception of the potato crop, are relatively of less value as human food than grain crops, part of the area which would normally be available for root crops should be again sown with cereals. Wheat may be sown in autumn on such soils as are suitable, or oats may be sown in spring. Avel cropping can be practised with great advantage in the case of land that formerly was under pasture

for several years, as in such cases time is required to break down the old turf, and while it lasts there is abundance of organic matter present. Even in such cases it is generally necessary to manure fairly liberally in order to obtain the best results, as the first crop uses up the more readily available portions from the reserves of plant food material in the soil.

Again, in the case of land which is full of couch or otherwise foul, avel cropping constitutes an excellent method of cleaning and preparing such land for the root crop. For this purpose a variety which gives a big yield of straw should be selected and encouraged by manuring, in order to raise a heavy crop, smother the weeds, and clean the land.

Provided that avel cropping is practised with discretion, and that it is accompanied by judicious manuring when required, the practice has much in its favour and little in the way of drawbacks. It would, however, be a great mistake to take two white crops in succession from land in poor condition without making adequate return, and in introducing this modification in cropping care must be taken to see that it is only adopted under conditions that are favourable.

Bare fallowing.—This custom of dealing with some of the very heaviest land, and practised from time immemorial, can only be justified under very exceptional circumstances at the present time. The benefits which accrue from the practice are well known, but it means making a sacrifice now for the sake of future benefits. The production of food two years hence is likely to be very important, but it is not so vital as the production of food to-day; and land which under ordinary conditions would be bare fallowed and sown with wheat in the autumn should be cultivated in such a way as to contribute to the food supply without sacrificing a year. Wherever possible a crop of beans should be taken, in view of the special value of that crop, now that feeding-stuffs are so scarce, and its suitability for heavy land. Moreover, this crop forms an excellent forerunner for wheat, and can be grown in such a way as to admit of intertillage till well on in summer. Even a crop of roots, rape, or thousand-headed kale, for consumption by sheep, would be of considerable value, being very much preferable under war conditions to "bare fallow," and, failing a

more valuable crop, such could be grown with material benefit and without detriment to the future cropping capacity of the land under consideration.

Shortage of Pasture.

One of the most difficult problems likely to arise from an increased area under the plough will be that of maintaining the same head of stock with a materially lessened area under pasture, more especially as much of the finest pasture land will require to be put under crop, and consequently will no longer be available for grazing purposes. There are several methods of eking out a short pasture supply, and in the next few pages a few possible methods are briefly considered.

(1) *House-feeding rather longer in spring to let the grass well up before putting stock on to it.*—When this can be done the pasture will carry a heavier head of stock throughout the remainder of the grazing season; but if, on the other hand, the fodder gives out too soon, and stock have to be put to pasture before the grass has got a good start, it never stands the same amount of grazing. If stock can be house-fed for even an extra fortnight, particularly in the month of May, a smaller area of pasture can be made to maintain them during the summer and autumn.

One of the main difficulties in carrying out this scheme is to have a supply of succulent food for the late spring and early summer months. Suitable forage crops can be grown in England, particularly in the south, but the more severe climate of Scotland makes the task here a more difficult one.

A sufficient supply of swedes or, better still, of mangels, would answer the purpose quite well, but in addition to these crops there are at least two others, namely, thousand-headed kale and a mixture of winter rye and vetches, which could be made much more use of than is the case at present.

Thousand-headed kale, in the opinion of the writer, has several merits which do not appear to be fully appreciated. It gives a heavy yield per acre, and is relished by almost all classes of stock. It can be grown to produce a supply of succulent food available for use from September right on until the end of May.

The crop has the additional merit that it will stand a very severe winter without any damage resulting, but as one would expect during snowstorms, especially if prolonged, birds are sometimes attracted by the mass of green foliage, and may cause some damage. They do not destroy the crop, as it sprouts out all round in a most remarkable manner in the early spring months, and justifies the name of "thousand-headed."

For use in late autumn or early winter the crop should be sown in the end of April or beginning of May, 5 to 6 lb. of seed being sown per acre. It generally gives the best return if the seed is drill-sown in the same way as for the turnip crop, and the plants spaced out later to about 2 feet apart. This is a safe method of growing kale, being much more certain than transplanting, which sometimes fails.

For use in March, April, or May it is better to delay sowing until the month of June or the beginning of July, as when sown at that time the crop gives a very large amount of produce in the spring and early summer months, and does not so readily run to seed as when it is sown earlier in the season.

The produce from the crop is very valuable for dairy cows, fattening cattle, ewes, and lambs, and even for poultry, especially if confined to runs. Its merits are such as to justify its cultivation under ordinary conditions, and now that there is even greater need for producing succulent food for use in late spring and early summer, it might play a particularly important part in a scheme of cropping adapted to war conditions.

A mixture of winter rye and vetches constitutes another very valuable crop, and where it can be successfully grown it produces a large amount of succulent food for use about the month of May, and this when utilised in the feeding of stock enables them to be kept a little longer indoors, and therefore lets the grass get a better start, with the result already referred to.

The crop cannot be successfully grown unless in somewhat sheltered situations, and on reasonably good soils. The vetch

particularly is apt to suffer from severe frosts in winter, and may be entirely killed out. To get it well established before winter sets in it should be sown prior to the end of September. The Siberian vetch has been found to be very much hardier than the ordinary vetch; moreover, it is ready for cutting earlier in spring, which is a great advantage. Unfortunately, on account of the war, seed of this variety is practically unobtainable at the present time.

In preparing the ground for this crop a dressing of farmyard manure should always be applied, as this contributes greatly to successful cultivation. A mixture consisting of $1\frac{1}{2}$ bushels of winter vetches and 2 bushels of winter rye makes quite a suitable seeding.

There is never any difficulty in getting the winter rye to succeed, but the winter vetches are a much more precarious crop to raise, though under the conditions indicated they are likely to succeed well, and to prove specially valuable in early summer for cutting and feeding green to dairy cows and other classes of stock.

(2) *Soiling during Summer.*—This is another method of keeping a large head of stock, even with a very limited area under grass, forage crops being cut and fed to the stock indoors or spread out on the pasture. Soiling during summer is widely practised on the Continent, but for some reason or other it has never become popular in this country.

An acre of land under a valuable forage crop will produce a much larger amount of summer food than if the land is under pasture. One acre of good land under pasture may maintain a cow in full milk during the whole of the grazing season, but an acre under productive forage crops may be made to maintain as many as three cows for the same period. There is, of course, much extra labour involved in connection with cultivation, cutting, carting, and feeding, but the extra labour involved is well repaid by results.

Of the various forage crops that may be grown for this purpose, Lucerne, while very suitable under the more favourable climatic conditions which prevail in the South, has not proved at all suitable under Scottish conditions, and its cultivation cannot be recommended.

A mixture of winter rye and vetches for the early part of the year, and of spring-sown vetches and oats, or peas and oats, for summer and autumn use, are likely to prove very much more suitable. The crops for summer and autumn use are very easily grown, and successive sowings will provide a valuable supply of succulent food for the whole period; but the winter crop, as already indicated, is more precarious to raise. On the whole, vetches and rye or oats, and peas and oats, are the most suitable forage crops for soiling in Scotland, and by their use, even on a relatively small scale, it is possible to maintain the same head of stock on a greatly reduced area. Not only so, but if part of the crop should not be required for soiling purposes, it will be found that the mixtures referred to, if cut sufficiently early and secured in favourable weather, will furnish a valuable, palatable, and highly nutritious fodder, which to some extent will lessen dependence on concentrated feeding-stuffs during the winter.

In certain districts where early potato-growing is combined with dairying, barley has proved an exceedingly useful crop for soiling purposes. It is sown just after the potatoes are lifted, and is ready for cutting in autumn. In very favourable seasons the crop is allowed to mature, and a fair yield of grain is obtained.

(3) *Sowing Clover with Lea Oats.*—This is a practice which could be much more widely adopted with excellent and far-reaching results. It is an excellent method of providing much valuable grazing just at the time of the year it is likely to be most required, and it also greatly enriches the land and thus benefits future crops.

Red clover is the most suitable clover for sowing for this purpose, and for success it is essential that the soil be fairly clean and otherwise suitable for clover growth. The seed should be sown at the rate of 4 lb., or thereby, per acre, after the oats have been harrowed or drilled in. The clover-seed should be very lightly covered by the use of a light harrow, and then firmly rolled in.

Experiments carried out by the West of Scotland Agricultural College, and extending over a period of three years, showed that red clover sown with lea oats produced an increase

the following year in a succeeding crop of barley, amounting to fully eight bushels of grain per acre, as compared with the yields from plots not sown with red clover in the previous year. In these experiments the clover was not grazed after the removal of the oat crop, but was allowed to grow until the end of the season, and was then ploughed in; but even though the clover is grazed, as is suggested above, the soil would still be very materially enriched in nitrogen, and the succeeding crop would benefit greatly, though not to quite such a marked extent as when the whole of the produce was ploughed under.

The sowing of clover with lea oats for the provision of autumn grazing, and the ploughing in of the residue, also constitutes a very suitable method of preparing land for wheat, when it is deemed advisable under war conditions to depart from the usual rotation and follow oats with wheat.

Taking everything into consideration, the practice of sowing clover with lea oats, under favourable conditions, is to be strongly recommended at the present time as a means of providing valuable grazing when the pastures fail in autumn, and also because of the very great benefits which succeeding crops derive from the enriching of the soil in nitrogen.

(4) *Seeding and Manuring.*—Apart from the methods briefly referred to which might be adopted in order to enable the same or even a larger head of stock to be maintained with a lessened area under grass, much may be done to improve the stock-carrying power of pasture-land by paying special attention to the seed-mixture in the case of rotation grass, and by judicious manuring in the case of both rotation grass and permanent pasture.

With regard to rotation pasture, in deciding on a suitable mixture of seeds, special attention should always be paid to climate and altitude, nature of soil and sub-soil, duration of pasture, &c., and the aim should be to include in the mixture the seeds of suitable plants in proportions calculated to furnish the maximum amount of grazing during the years the land is under grass. In this connection the special value of red and alsyke clover, and of vigorous growing top grasses, like Italian (in moderation), cocksfoot, timothy, tall oat, &c., according to conditions, has been clearly demonstrated, as well as the great

benefits which accrue from including wild white clover in mixtures for all pastures on suitable land that have to be down for more than two years. Wild white clover is a plant which spreads very rapidly once it is established, and the inclusion of even half a pound of seed per acre in the mixture soon adds materially to the stock-carrying power of the pasture. The benefit does not end there, indeed it is only beginning, for when the pasture is again broken up the soil is so rich in nitrogen, which has accumulated as the result of the clover growth, that large grain crops can be raised with phosphatic manures alone, no artificial nitrogeneous manures being required.

The cost of wild white-clover seed is considered by many to be prohibitive at the present time. It certainly commands a high price, but from long experience and close observation the writer considers that the benefits accruing from its use are so great that, under war conditions, when every acre must be made to produce as much as possible, the inclusion of wild white-clover seed, even at the present price, in mixtures that are to be down for more than two years, is justified by results.

As regards the improvement of pasture by manuring, there have been in recent years so many striking object-lessons in this connection, including the very excellent one recently reported on by Dr. Somerville in the February number of the *Journal of the Board of Agriculture*, that further comment seems superfluous. We know what basic slag and other manures can do in the way of effecting improvement in pastures, and there is not the slightest doubt but that the stock-carrying capacity of many of our pastures could, through judicious manuring, be speedily raised by from 25 to 50 per cent., without in any way militating against the progress—or milk yield in the case of dairy cows—of the individual animals. In fact the reverse is the case, for not only does the grazing carry a heavier head of stock, but the individual animals do better. Manuring of rye-grass and clover or other hay land in midsummer, as soon as the ground is cleared, might also with advantage be more widely adopted. The aftermath would be much more abundant, and growth would be somewhat prolonged, consequently the period of

winter feeding would be shortened. Superphosphate and sulphate of ammonia are very suitable artificial manures for this purpose.

In closing, it should perhaps be pointed out that no hard and fast rule can be laid down as to what would constitute the best system of cropping under war conditions, as that must always depend very much on the system of farming pursued. On a dairy farm, for example, a big proportion of the crop grown will be required for the winter feeding of the stock, and a crop of wheat, though particularly valuable as a direct source of human food, would in such circumstances prove less suitable in the long run than grain crops like oats and beans. Again, on farms entirely arable in character, and on which stock are to some extent a secondary consideration, a considerable area can generally be devoted to the production of wheat and potatoes, as these are the crops which, under suitable conditions, provide the greatest amount of food for direct human consumption.

No matter what system of cropping is followed, there must certainly be a considerable increase in the area under the plough, on account of the relatively higher return for human food derived from land under crop as compared with land under grass, but every acre of land under the plough should be made to produce all that it is capable of yielding.

The production of large crops is specially important, but it is equally important that the numbers of stock be kept up, in view of the large amount of straw likely to be available for fodder, and because the production of farmyard manure on a much bigger scale than formerly will be essential to keep up the fertility of the increased area under the plough.

If we look a little ahead to the day when this grievous war shall have ended, the bigger area under the plough will serve another very useful purpose, as it will permit of a much larger proportion of those returning to civil life being absorbed into agriculture than would be possible if the area under the plough was no greater than in the years just prior to the war.

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REPORTS.

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REPORTS

ON

DEMONSTRATION POULTRY CROFTS;

EXPERIMENTS IN THE MANUFACTURE OF RENNET;

THE PRODUCTION OF HONEY;

A COMMON DISEASE OF POTATOES;

SUGAR-BEET TRIALS, 1918;

SOME BEE DISEASES;

CATTLE-FEEDING EXPERIMENTS;

BUTTER-MAKING ON THE FARM.

Sixteenth and Seventeenth Annual Reports.

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GLASGOW, 1921.

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NOTE OF ACKNOWLEDGMENT.

The Governors of the College have pleasure in expressing their indebtedness to farmers and others who gave facilities for the carrying out of certain of the experiments dealt with in this Report, and who incurred much trouble, and not a little expense, in their careful supervision and execution.

Bulletin No. 91.

The West of Scotland Agricultural College.

REPORT

ON

DEMONSTRATION POULTRY CROFTS

AT

TIREE AND GLENLUCE,

BY

THE COLLEGE INSTRUCTRESSES

FOR THESE DISTRICTS.

Glasgow:
Printed by Robert Anderson, 142 West Nile Street.
1919.

Report on Demonstration Poultry Crofts.

THE College, having in view the necessity for the adoption of modern and profitable methods of poultry-keeping, especially amongst crofters, cottagers, and small holders, made arrangements for the establishment of a few Demonstration Crofts in the more remote areas served by the College. These Crofts were equipped with modern houses and pure-bred stock likely to suit the locality, and provision was made by the College for their periodical inspection and general supervision by the instructresses in poultry-keeping for the districts in which they were established. This report summarises the results obtained up to the present time.

KIRKAPOL, TIREE.

Cost of rearing chickens in 1915, from March to 30th September, on which date the pullets were housed.

60 chickens were reared and 36 kept for stock (19 being Rhode Island Reds and 17 Black Leghorn Pullets).

Receipts.			*Expenditure.*			
7 Cockerels @ 2/-,	£0	14 0	Sittings of eggs, -	£0	12	4
7 do. @ 1/9,	0	12 3	Grain, - -	2	11	3
9 do. @ 1/3,	0	11 3	Meals, - -	2	12	9
			Sundries, - -	0	0	10
	£1	17 6				
Eggs laid in Sept.—						
30 eggs @ 1¼d. each,	0	3 1½				
27 eggs @ 1½d. each,	0	3 4½				
	£2	4 0		£5	17	2

The above works out at 2/- per pullet kept for stock.

The birds were fed on biscuit meal, bran, thirds, oatmeal, wheatmeal, and buttermilk; alternately with dry seeds, consisting of cockle wheat, groats, cracked seed-corn, broken rice, and dari.

Biscuit meal was discontinued after the fourth week. Coarser feeding and oats were given as the birds grew up.

Laying results of *pullets*, period 1st October, 1915, to 30th September, 1916 :—

19 Rhode Island Reds (single comb)—3,706 eggs laid.
Average, 195 per bird.

17 Black Leghorns—3,217 eggs laid.
Average, 189 per bird.

Receipts.				*Expenditure.*			
For eggs, - -	£45	8	2¼		£20	6	4
				Profit, - -	25	1	10
	£45	8	2¼		£45	8	2

Yearly profit per bird—13/11.

Average price received for eggs—1/7 per dozen.

Weekly cost per bird for food—2½d.

Results of above birds in their second season, with 14 Rhode Island Red pullets included—period, 1st October, 1916, to 30th September, 1917 :—

18 Rhode Island Red Hens,
14 Rhode Island Red Pullets, } 3,810 eggs laid.
Average, 119 per bird.

17 Black Leghorn Hens, 1,933 eggs laid.
Average, 113 per bird.

Receipts.			*Expenditure.*			
£54	8	1¾		£33	0	9
			Profit, -	21	7	4
£54	8	1¾		£54	8	1

Yearly profit per bird—9/6.

Average price received for eggs—2/0½ per dozen.

Weekly cost per bird—3d.

It is clearly more profitable to have pullets when the eggs are sold only for marketing purposes.

The Black Leghorns were kept on the semi-intensive system and never allowed out in bad weather. Both breeds were enclosed in wire-netted runs facing the Atlantic.

The houses had to be fastened down with wires attached to posts driven into the ground. They were provided with open fronts but were fitted with strong double canvas shutters in winter.

The Rhode Island Reds, being in a movable house, were drawn on to the stubble after the crops had been secured and this helped to keep down the food bill

The following is an example of the rations used in 1916, for 20 fowls :—

Morning Mash.—8 oz. bran (scalded), 8 oz. thirds, 2 oz. oatmeal or ground oats, 2 oz. potatoes or turnips, well mashed. Buttermilk was given to drink when available.

Mid-day and Evening Grain.—The grain was principally oats, occasionally a little wheat was added and, in winter, some Indian corn.

The quantity of grain allowed was about 1 lb. at mid-day and 2½ lbs. in the evening. Green stuff and raw turnips were supplied constantly throughout the winter and when grass was scarce. Plenty of shell grit is got from the shore, but all feeding stuffs, including grain, have to be shipped from Glasgow, the high freight charges adding considerably to the cost. Sand is used for covering the dropping boards. The droppings being removed daily, the houses are spotlessly clean, and a clean poultry house ensures clean nests and eggs and keeps the birds free from vermin.

Returns from 24 (S.C.) Rhode Island Reds (15 hens and 9 pullets).—Period, 1st October, 1917, to 31st September, 1918 :—

3,874 eggs laid = 161 per bird per annum.

Receipts.				*Expenditure.*			
For eggs, - -	£58	1	11	Meals and grain,	£18	3	1
				Potatoes, buttermilk, &c., -	1	10	0
				Cockerel and freight,	0	14	9
					£20	7	10
				Profit, - -	37	14	1
	£58	1	11		£58	1	11

Yearly profit per bird—31/5.

Yearly average price for eggs—3/7 per dozen.

Weekly cost per bird for food—3¾d (semi-confined).

Returns from 17 Black Leghorns (all second season birds).—Period, 1st October, 1917, to 12th July, 1918 (40 weeks) :—

1,327 eggs laid = 78 eggs per bird for 40 weeks.

Receipts.				*Expenditure.*			
For eggs, -	£20	2	6	Meals and grain,	£11	5	4
				Turnips, potatoes, and buttermilk,	1	0	0
					£12	5	4
				Profit, -	7	17	2
	£20	2	6		£20	2	6

Profit per bird (40 weeks)—6/6½.

Average price for eggs per dozen—3/7½.

Weekly cost of keep per bird—4¼d. (confined run).

Rations used, 1917-18.

24 Rhode Island Reds and 1 male bird.

Soft Food.—Bran, 8 oz. ; thirds, 6 oz. ; bulko, 8 oz. ; potatoes or turnips, 3 to 7 oz. ; grain, $2\frac{1}{2}$ to 3 oz. per day per bird. Buttermilk given to drink when available.

In 1918 grain became very scarce and a different method of feeding was tried in order to save it. 1 oz. of grain was given per bird in the litter at breakfast and a hopper of dry mash was left open for the birds from 11 a.m. till 2 p.m in the afternoon.

The dry mash consisted of 35 parts bran, 35 parts thirds, 30 parts bulko or ground oats. Soft food was given in the evening as much as the birds would eat, about the following quantity :— 14 oz. bran, 12 oz. thirds, 12 oz. ground oats, 12 oz. potatoes or turnips.

The Black Leghorns had much the same treatment but were allowed rather more grain in the litter for the whole period.

BRIDGEMILL, GLENLUCE.

Owing to the time of year at which the Glenluce Croft was started, it was found difficult to procure pullets, and second-year birds (Rhode Island Red and Black Leghorn) were obtained instead.

The birds purchased, while of a good laying strain and very suitable for breeding purposes, did not give the high average egg yield obtained from pullets.

A few of the hens considered to be extra good layers were retained in their third season, but this can only be justified in exceptional circumstances, and as a general rule is not to be recommended.

Particulars regarding returns are as follows—period, 9 months (January to September 30th, 1916):—

39 birds (24 Rhode Island Reds and 15 Black Leghorns).

Receipts.		*Expenditure.*
£33 13 8		£16 12 4
	Profit, -	17 1 4
£33 13 8		£33 13 8

Profit per bird for 9 months—8/9.

65 dozen eggs were sold at 3s. per dozen as sittings. The rest were sold locally at an average of 1s. 4d. per dozen.

Ration for 38 *Fowls.*

Morning.—Bran, 12 oz.; thirds, 8 oz.; ground oats, 8 oz.; boiled fish-heads, &c., 10 oz. = 1 oz. per bird.

Mid-day.—Oats or wheat, 38 oz.; in winter steamed and fed warm. = 1 oz. per bird.

Evening.—Oats, wheat, and Indian corn, equal parts, 57 oz. = 1½ oz. per bird.

Results from 1*st October*, 1916, *to* 30*th September*, 1917:—

72 birds. Rhode Island Reds and Black Leghorns.

Eggs laid, 7,077; average, 99 per bird.

Receipts.		*Expenditure.*
£71 9 2½		£50 2 6
	Profit, - -	21 6 8½
£71 9 2½		£71 9 2½

Hens' Rations.

Morning Mash.—Bran, 8 oz.; bulko, 5 oz.; cut oats, 5 oz.; thirds, 8 oz.; potatoes, 8 oz.; fish meal, 14 oz.

Mid-day.—Oats, 3 lbs.

Evening.—Mixed grain, 4½ lbs.

Pullets' Rations.

Morning Mash.—Bran, 6 oz.; bulko, 3 oz.; cut oats, 4 oz.; thirds, 4 oz.; potatoes, 3 oz.; fish meal, 7 oz.

All fowls were allowed greens and turnips, as a proportion of vegetable food is very necessary to the health of the birds.

A constant supply of grit was provided. At the end of the hatching season, about the end of May, the pens were broken up and all male birds sold off, the advantage of this being that the eggs keep fresher and food is saved.

No cropping is carried out on this Croft so that the birds had not the advantage of stubble, and the feeding bill was higher on that account. This will be remedied next season, as it is proposed to sow oats in one of the fields.

Returns for 74 Fowls.—Period, 1st October, 1917, to 30th September, 1918:—

Receipts.		*Expenditure.*	
£133 12 2	Meals and Grain,	£49 5 0	
	Cockerels, - - -	1 2 6	
	Carriage on eggs,	1 9 2	
		£51 16 8	
	Profit, - -	81 15 6	
£133 12 2		£133 12 2	

Profit per bird—22/1 per annum.

Average cost per bird—3½d per week.

Average price of eggs—4/2 per dozen.

Cost of Chicken Rearing for 1916 *and* 1917.

1916.—The following amount of food was consumed :—56 lbs. biscuit meal; 56 lbs. cockle wheat; 21 lbs. groats; 112 lbs. bran; 126 lbs. thirds; 147 lbs. oatmeal; 56 lbs. dari; 28 lbs. broken rice; 441 lbs. oats; 56 lbs. Indian corn (cracked).

Expenditure.

Food, - - - -	£6	19	2
Sittings, - - - -	3	9	6
	£10	8	8

52 cockerels were sold at 2/2 and 3/3 each, bringing in £7 2/-.

58 pullets were kept for stock.

The chickens were hatched by hens, the hens being confined in coops and the chickens fed apart after the first few days.

1917.—Cost of rearing 104 chickens. Hatched in incubator and reared in brooders.

Foods consumed. — 224 lbs. biscuit meal; 70 lbs. broken rice; 91 lbs. groats; 35 lbs. oatmeal; 105 lbs. thirds; 28 lbs. bran; 56 lbs. cockle wheat; 14 lbs. meal seeds; 89 lbs. dari; 168 lbs. Indian corn; 28 lbs. potatoes. Carriage on goods, 5/1. Total cost of 94 chickens (10 died), March to August, £13 1s. 2d.

47 cockerels sold at 2s. 6d. to 3s. 4d. each,	£6	10	0
14 pullets sold at 5s. each, - - -	3	10	0
	£10	0	0

33 pullets kept for stock.

1918.—Cost of rearing 125 chickens. Hatched and reared as in 1917. Foods consumed :—224 lbs. biscuit meal; 112 lbs. dry chick feed; 273 lbs. groats; 49 lbs. oatmeal; 280 lbs. bran; 56 lbs. cracked Indian corn; 370 lbs. oats; 84 lbs. meal seeds; 42 lbs. meat meal; 10 stones potatoes.

Food (including carriage), - -	£18	14	9
Sittings, - - - - -	8	16	6
	£27	11	3

62 cockerels sold for marketing, -	£9	7	6
12 pullets sold for stock purposes, -	6	3	6
	£15	11	0

51 pullets kept for stock.

Cost per pullet—4/8½.

The R. I. Reds were moved on to the stubble after the grain crop was harvested, and required very little artificial feeding for a period of about six weeks.

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West of Scotland Agricultural College.

EXPERIMENTS

IN THE

MANUFACTURE OF RENNET.

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MANUFACTURE OF RENNET.

RENNET is a liquid extract used for coagulating the milk in cheese-making, and, on a smaller scale, for making junket. It is also employed in the preparation of commercial casein from separated milk.

The active principle in rennet extract is an enzyme called *rennin* or *chymosin*, but another ferment, *pepsin*, is almost invariably present. The properties of these two enzymes are very similar, and many physiologists hold that they are identical. This identity is difficult to substantiate, because it is doubtful whether either enzyme has yet been prepared in a state of absolute purity. It is better to regard them as two distinct, though closely related, proteolytic ferments, with properties which are similar, but some of which are more accentuated in the one enzyme than in the other. Both enzymes curdle milk and (in the presence of acid) subsequently assist in digesting the curd. But rennin or chymosin has the greater coagulating power; while pepsin has the greater digestive effect.

Experiments have shown that, while commercial pepsin can be successfully substituted for rennet in cheese-making, there are differences, small but distinctive, in the primary effects of each on the cheese milk.

Animal Rennets.

The rennet of commerce is an extract of the fourth stomach ("reed," "vell," "yearnin, "maw skin,") of the suckling calf; practically all the rennet produced in Britain is derived from this source.

Rennet, however, is present in the gastric glands of all young mammals, and thus we occasionally find it extracted from the digestive apparatus of the sheep, goat, and pig. In the Highlands of Scotland home-made rennet is sometimes prepared from the stomach of the young deer.

In smaller amounts rennin occurs in the intestine—especially the small intestine—of all milk-producing animals, in the pancreatic and gastric juice, and also in the urine.

Vegetable Rennets.

Besides rennets of animal tissues, there are rennets of purely vegetable origin which are equally capable of curdling milk. They are to be found in the leaves, fruit, and grains of certain plants. The flowers and leaves of artichoke and the juice of the fig-tree contain a rennet enzyme. The grains of *Withania coagulans* give a strong rennet extract, with glycerine or salt. *Drosera*, *Datura Stramonium* (thorn apple), *Pisum sativum*, *Lupinus hirsutus*, *Ricinus hirsutus*, *Galium verum*, and *Penguicula vulgaris* all yield rennet. According to Effront, the last two have been used by the dairymen of certain Continental countries for the manufacture of cheese. During the war extract of *Cynara cardunculus* has been used in Italy and in Germany instead of rennet in cheese-making. These vegetable rennets have certain differentiating characteristics which distinguish them from animal rennets.

Microbial Rennets.

Duclaux (*Microbiologie*, p. 131) has shown that rennet is secreted by certain microbes which curdle casein and which dissolve it, but only after they have first effected its coagulation. (These bacteria also secrete another enzyme, *casease*.) Typical examples are *Tyrothrix tenuis* and *B. prodigiosus*.

Serums behaving like Rennet.

If the milk of one animal be injected subcutaneously into a second animal, the serum of the latter will acquire the property of coagulating the milk of the former. But rennet injected in a similar manner produces in the serum an antibody which delays coagulation. This antibody occurs abundantly in horse serum.

Acids and Salts behaving like Rennet.

Hydrochloric, sulphuric, and mineral acids generally, precipitate casein as do also certain acid salts. The curd so produced, however, may be redissolved by alkali, while a rennet curd cannot be dissipated in a similar manner. Oxalic acid and hydrofluoric acid remove the lime salts from milk and prevent rennet coagulation.

Neutral salts of the alkaline earths coagulate milk after the manner of rennet, but the optimum temperature for their

action is 100° C. while the optimum for rennet is 40° C. For instance, 0·5 per cent. crystalline $CaCl_2$ will curdle milk in a few minutes at the boiling-point.

DIFFERENT METHODS OF EXTRACTION.

The properties required in a good brand of rennet are; clearness of solution, strength of extract, good keeping qualities, and the absence of undesirable bacteria. To achieve all these is a really difficult matter, and consequently the process of extraction and clarification of rennet on a manufacturing scale is kept a closely-guarded trade secret. Chemical analysis of commercial rennets will afford little information of any value. It will tell nothing of the process of extraction or of the method by which the extract has been cleared, and these are points of prime importance.

(*a*)

Lindet (*Le Lait*, p. 296) gives the following method of preparing rennet:—"The fourth stomachs of young calves are lightly scraped to remove particles of curdled milk which adhere to the internal mucus. The employment of water in this operation should be avoided, otherwise there is a loss of ferment. The stomachs, tied at one of their extremities, are then inflated and the other end tied. They are then suspended and dried in a well-ventilated hanger.

"The vells, dried and cured, are cut into strips by a meat cutter, and are macerated in cold water as free from germs as possible. One or more antiseptics may be added, but formic aldehyde should not be used, as it destroys the enzyme. The extract is filtered, either through paper or across the cloths of a filter-press. The residual mass is steeped a second time in water, and the extract gives rennet of a lower strength."

(*b*)

Effront (*Moniteur Scientifique*, May, 1909) advocates the following procedure:—"The stomachs are freed from granules inside, washed well with water, and immediately inflated. They are dried for 10 days, cut up into small pieces, and macerated in water containing 4 per cent. boric acid, at 30°C., for 4-5 days, employing 100 grs. dried vells per litre water. Instead of boric acid, 3-6 grs. common salt per litre may be used; but a salt extraction

should be made at 15-20°C. The preliminary drying of the vells is designed to obviate the viscosity of the liquid rennet. For the same purpose, the pylorus part of the stomach is cut off prior to extraction. The resultant solution is active, but contains much foreign matter; to purify it recourse may be had to fractional precipitation by alcohol, collecting and drying the precipitate in vacuo. The product so obtained is a white, very active, powder, but mixed with other enzymes."

Rennet prepared by the above process is considerably weaker than commercial rennet and has comparatively poor keeping properties. The employment of water in cleaning the vells and the absence of any distinct curing period are both inimical to the production of a clear solution.

(*c*)

The original process of extraction, as described by Soxhlet (*Milch Zeitung*, 1877, p. 497) has long been recognised as the standard method of preparing rennet on the farm, and, with certain modifications, it may be regarded as the basis of the modern commercial processes. It is as follows:— The stomachs are cleaned—but not washed—distended, air-dried, and cured for three months. When ready to extract, the part of the stomach which contains no folds is removed, and the rest cut into pieces about 1 sq. c.m. in size. To each 100 grs. stomach 1 litre H_2O. 50 grs. salt, and 40 grs. boric acid are added, and the whole left to stand for 5 days at the room temperature. Then other 50 grs. salt per litre are added and the fluid filtered off. To this solution is added one-fifth of its volume of a 10 per cent. salt solution, saturated with boric acid.

Such an extract is muddy and loses strength rather quickly for the first few weeks. When a constant strength is reached, it is considerably weaker than the rennets of commerce.

The turbidity of the solution is due principally to the presence of mucus, which is always favoured by an acid extraction. Any attempt to remove this mucus will usually result in the loss of the greater part of the enzyme. If the filter is sufficiently porous to prevent rapid clogging, the emerging solution will still be turbid. On the other hand, if the filtering medium is very close, it will be quickly choked by the slime. If pressure be applied to force the liquid through, the rennet obtained is clear,

but very weak. The mucus deposit on the filter renders filtration very slow, and retains the greater part of the enzyme. Nearly all close filters appear to possess great adsorbing powers for enzymes.

The colloidal character of the suspended material prevents it sedimenting out, and hence the solution does not clear, even after long standing.

(*d*)

To obtain a pure rennet extract free from other enzymes Hammersten's method may be adopted. As a source of rennet he employs the mucous layer of the stomach of a young calf, dried at 35-40° C. The operation is carried out according to the procedure of Ebstein and Grutzner in the following manner:—

"The stomach is slit along its lower aspect, and then opened out with the mucous layer downwards. The muscular tissue is then shaved with a razor and the pouch then spread on filter paper, the mucous layer outwards, and dried at 35-40° C. When dry the paper is removed. The horny substance so obtained is cut into small pieces, and may be kept in a sealed vessel for a long time without loss of activity.

"To obtain a solution of rennet, fragments of this material are macerated with water or glycerine, using 1 gr. dried mucous membrane per 100 c.c. water. The solution is very active; the extraction from 1 gr. can coagulate 5-10 litres milk in 30 minutes."

This method is useful for making rennet on a laboratory scale, when an extract of great purity is required for standardising purposes, or for determining the properties of the rennin enzyme.

(*e*)

Duclaux extracts prepared vells with pure water at 30-35° C., or with weak acids and salt solutions at a lower temperature. This authority states that a 3 - 6 per cent. salt extraction for 5 days at the room temperature will give a strong solution, if the extract be frequently stirred, and the liquid, before decanting, be additioned with other 5 per cent. salt. Suitable antiseptics may be added to the solution.

Many other formulæ have been published; but nearly all are modifications of one or other of these methods. It is significant that most authorities agree that a preliminary

drying and curing of the vells is necessary for the production of a satisfactory rennet solution: experience and experiment have shown that the extraction of fresh vells gives a turbid, slimy, and impure rennet which ferments quickly and has poor coagulating powers.

An extended series of experiments on the manufacture of rennet was conducted at the Dairy School, Kilmarnock, during the sessions 1917-1918. The primary object of this investigation was to determine whether a satisfactory brand of rennet could be made by a comparatively simple process of manufacture from home-cured vells. But the inquiry was not limited to this alone; and exact information on the factors which contribute to the production of a pure high-grade rennet was sought.

SPECIAL PROCESS OF MANUFACTURE.

It was early made apparent that much of the success in rennet making depends on the selection, treatment, and curing of the vells, and that the efficiency of extraction, as well as the ease of clarification, are profoundly affected by the condition of the raw material. Impure and bad-smelling rennets are almost wholly due to lack of care in handling the vells in the fresh condition, and to their faulty preservation during the curing stage. Some of the cured vells of commerce have been particularly badly handled.

Selection of Vells.

The strongest extractions and the most satisfactory rennet solutions are obtained from the vells of milk-fed calves not more than a week old at the time of slaughter.

As already indicated, rennet contains two enzymes—chymosin, which has the greater coagulating effect; and pepsin, which has the greater digestive action. The secretion of stomach of the very young animal consists very largely of chymosin. As the calf grows older, the chymosin secretion decreases for the first 5 months, while the pepsin secretion remains constant or increases. Hence extractions from the stomachs of very young calves may have 3-4 times as much coagulating power as those from older calves, though the digestive action of the latter may be greater.* In the case of older animals, the coagulation of milk by the stomach extract is due almost entirely to the action of pepsin.

* *Z. Physiol. Chem.*, **70**, 171.

The superiority of the extract from very young calves' stomachs rests not only on its greater coagulating powers, but also on the greater purity of the solution. It will be obvious that the bacterial flora of the rennet will have a direct relationship to the feeding of the calf and that it will be richer and more varied with a mature calf than with a young milk-fed animal. In the latter case, the rennet extract will usually contain only typical milk organisms, while in the former case, spore-bearing and putrefactive organisms are likely to predominate.

Preparation of the Vells.

In the preparation of the vells, the following points should receive attention.

Immediately the calf is killed, the fourth stomach is severed from the entrails, leaving attached to it a small portion of the manyplies (third stomach) at one end and about 2 inches of the intestine at the other. This should be done, if possible, inside the body cavity, in order to avoid soiling the vell.

When removed from the carcases, the vells are placed singly over a clean receptacle—such as a barrow or wooden form covered with a newspaper. They should not be thrown on the floor of the abattoir or piled in a heap, as thereby soiling with dirt or with the oozing of the stomach contents can scarcely be avoided. The stomach of the young animal is practically sterile inside the carcase, and every attempt should be made to prevent unnecessary contamination.

If the calves are killed at the abattoir, and the vells have to be sent to the farm or the factory, the free ends are tied with a string in the form of a loop knot, and the vells placed in a clean waterproof bag for transport.

As soon as the vells are received from the slaughter-house no time should be lost in cleaning them. Any adhering fat or loose tissue is separated from the outer wall of the stomach as completely as possible. This should be done with a suitable knife—the cobbler's or skinner's knife is well adapted for this purpose—care being taken not to cut the wall of the stomach in removing the fatty tissue (see illus.)

The string on the pylorus end of the vell—*i.e.*, the end next the intestine—is then loosened, and the stomach contents gently squeezed out with the thumb and forefinger. The reed is then

turned inside out, any coagulated milk still adhering picked off, and the inner (mucous) surface uniformly salted, using a good but fairly coarse salt for the purpose. The stomach is reversed again and the outside salted heavily.

The expressed contents of the stomachs should consist mainly of curdled milk. If other foods are present, the extraction is not likely to be so strong; occasionally albumin and linseed are found; the albumin comes from eggs given to "slink" calves; the linseed from the milk substitute with which the calf has been fed.

One end of the vell being tied, a glass tube is inserted in the other, the stomach fully inflated, and the other end tightly tied with string.

In the process of scraping and cleaning the vells no water need be used. If the inner mucous surface is washed, much of the enzyme will be lost, and undesirable fermentation encouraged during the drying process. Neither will the outside wall require washing, unless the vell has accidentally fallen on the floor or been soiled in transit. In this case, the outer surface should be washed with a strong brine solution. When the vells have been properly handled, no other preservative than salt is necessary or desirable. If any of the vells are so badly smelling as to demand treatment with a preservative, they should be rejected altogether. The inclusion of a few such vells would contaminate a whole batch of rennet.

Curing the Vells.

Much of the success in rennet making depends on the proper curing of the vells.

The vells now blown up are tied together in pairs, and are dried over pulleys or wires, in a room with a good circulation of air, and at a temperature of 60-65° F. At the end of a fortnight or three weeks they should be quite dry, even at the ends. When this stage is reached, they are deflated, flattened out, and arranged in loose layers in crates, hampers, or open-work boxes, and stored in a dry room. On account of the salt they contain the dried vells are inclined to draw moisture during damp weather. This is more likely to happen when the vells are firmly compacted and a free circulation of air rendered impossible. The vells must be kept dry during storage, for in the presence of humidity the "rennets" weaken and undergo alteration.

The curing of the vells should take at least 3 months, but it may with advantage be continued for 4-5 months.

The object of drying the vells is to disintegrate or render insoluble the slimy mucous matter which is present in the fresh stomach, and which makes extractions of the latter viscous and foamy. It may be noted here that, although effective curing will get rid of most of this mucus, yet a small amount will remain unaltered, and will always appear in the subsequent extraction. But the longer the drying period lasts, the less mucus will remain unaffected.

We may also note that this mucus is not true mucin, but consists mainly of chondro-protein and nucleo-protein.*

Dried vells produce a purer rennet and an extract containing less pepsin and other enzymes than when fresh vells are employed.

Dried vells are also much more convenient to handle, and, if properly treated, contain relatively few undesirable bacteria.

Most rennet manufacturers, after cleaning the vells, inflate them directly without salting them. This method gives quicker drying, and the vells do not draw damp to the same extent during storage. But, on the other hand, they are much more liable to ferment before drying is completed, and they are usually much more "smelly," indicating that putrefactive bacteria are present. The rennet made from these vells has usually a "musky" odour.

The process of curing as outlined above adds to the cost of production, but the rennet made has no undesirable odour; it keeps well, and hence the method indicated is well worth adopting.

Process of Extraction.

When curing is complete, the vells are prepared for the extraction process. That part of the stomach—the pylorus end —which contains no folds is cut off and rejected, because it contains practically no rennet, and, if extracted, produces much mucus. The adhering portion of the third stomach is also discarded. The rest of the vell is cut up into small pieces ($\frac{1}{2}$-inch square); this may be done with special scissors, but on a large scale the cutting is usually done with a slicing machine, operating on the same principle as the chaff-cutter. This material, which furnishes *la premiere matière* from which concentrated

* *Biochem. Z.*, **56**, 167.

rennet extracts are prepared, is added to the extracting fluid at the rate of 10 per cent. by weight of the water used.

The composition of the extracting fluid is of first importance, because on it will largely depend the strength and purity of the resultant rennet solution. Each manufacturer has his own special formula.

The aim in extracting should be to produce a strong rennet containing little mucus, and to suppress undesirable fermentations during the period of steep. The extracting fluid should therefore favour the emergence, but have no injurious effect on the enzyme; it should have an inhibitive action on bacterial development, and it should not favour the extraction of mucus. It is doubtful whether a formula has yet been devised which is satisfactory in all these requirements.

The following recipe has been used with good results:—

Water,	100 lbs.
Salt,	5 ,,
$CaCl_2$,	5 ,,
Glycerine,	5 ,,
Dried Vells,	10 ,,

This gives a strong extract, containing comparatively little mucus and possessed of good keeping properties.

A simple salt extraction is sometimes quite effective; but, in this case, at least 10 per cent. by weight of salt should be used, and the process of extraction lengthened by several days.

The employment of acids in the extracting fluid materially lessens the period of extraction, but the resultant solution may contain much more mucus, unless very weak acids are employed. If this method be preferred—and it has the authority and support of many noted investigators—special attention should be given to the kind and the quantity of acid employed. The two most useful are phosphoric and hydrochloric acids. The former may be employed at the rate of ·05 per cent., and the latter ·02 per cent. At the conclusion of the extraction, the free acid should be carefully neutralised, using, for preference, bicarbonate of soda for this purpose.

In order to suppress undesirable fermentation during the period of steep, the addition of an antiseptic is necessary—especially when commercial vells are employed. The preservative selected must exercise no deleterious effect on the enzyme, or impart any

undesirable quality to the coagulated milk (as in junket), or to the cheese made with the rennet. Many of the better-known antiseptics and disinfectants have a destructive influence on rennin, *e.g.*, thymol, formalin, chloroform. borax, sodium salicylate, &c. Others could not be employed on account of their poisonous nature.

Iodine, or a solution of iodoform in glacial acetic acid, might possibly be used. These agents have a strong preservative action, and are without effect on the diastase. Unfortunately, the iodine would impart an injurious flavour to the curd, and consequently it must be removed or destroyed at the conclusion of the extraction process. This can be done after the manner of Morgenroth by precipitating it out with hyposulphite of potash. The precipitation process assists in clarifying the rennet.

Glycerine has distinct antiseptic properties, and is without effect on the enzyme. The addition of 10 per cent. glycerine to a rennet solution will keep it unchanged for about a year.

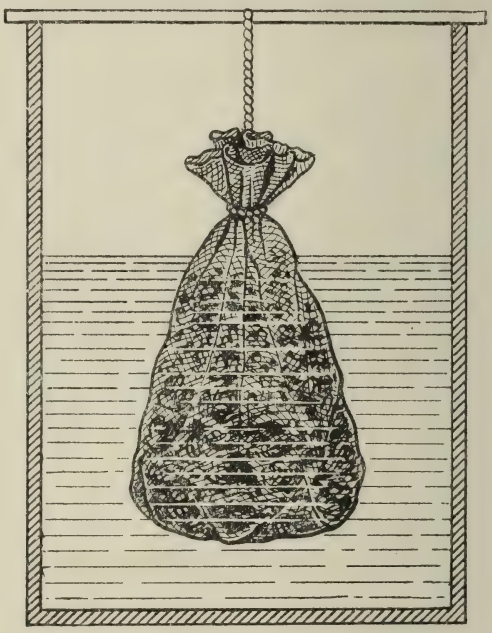
It is more usual, however, to employ boric acid, because it is odourless, imparts no marked taste to the solution, and in small amounts its presence in food-stuffs is harmless. Boric acid has the further recommendation that it activates the enzyme. Effective preservation is usually secured by employing 2-4 per cent. boric acid.

The water used should be clear and cold. It need not be soft; indeed, hard water is an advantage in rennet making. But it should be bacteriologically pure, and, if at all suspicious, it should be boiled and cooled. Distilled water, though the purest, is not well adapted for rennet; it seems to have a slight inhibitive effect on the enzyme.

The extraction should be made in a glazed earthenware vat (or in a crock, on a small scale), at the room temperature (55-60° F.). Extraction at temperatures over 70° F. is attended with many disadvantages, the chief of which are the increased amount of mucus in the resultant solution, and the loss of keeping properties of the rennet extract. When the temperature of steep is very low, the extraction is slow, but a clearer rennet is usually obtained, and this procedure should be adopted whenever the circumstances will permit of it. Extraction under pressure does not confer any material benefit.

Throughout the period of maceration, the vells should be stirred up and pounded daily. This accelerates the emergence

of the enzyme. If the extracting vat is of any considerable size, the cut-up vells should be put into a canvas bag of open mesh, and be suspended in the extracting fluid (see illus.).



The duration of the extraction process will depend on the weight of vells used per 100 parts water, the nature of the steep, and the temperature of the fluid. It may vary from 6 days to 3 weeks. If the conditions indicated above are adhered to, a concentrated extract will usually be got about the 12th day. For the first few days, the solution gains slowly in strength, but towards the end of the first week, the increase in strength is much more marked, and the solution begins to acquire the characteristic rennet smell. A prolonged steep usually results in a turbid rennet which is difficult to clear.

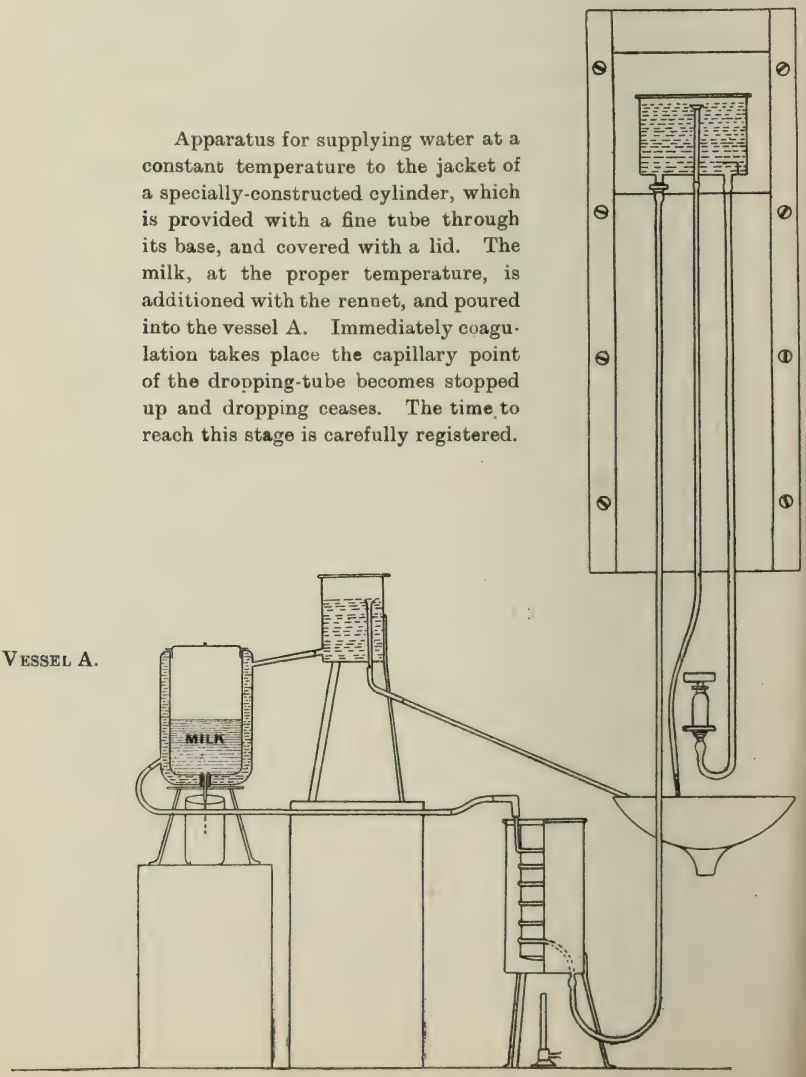
To determine the progressive accession of strength by the rennet solution during the period of extraction, a modification of the cheese-maker's rennet test may be employed. This consists in determining the time which a measured quantity of the rennet will take to coagulate a standard volume of normal milk, of definite acidity, at a selected temperature. Suitable constants

are :—1 drachm rennet ; 1 pint of milk of ·20 per cent. acidity ; a temperature of 95° F. When the time of coagulation is about $\frac{3}{4}$-1 minute, the rennet may be decanted off. A more exact procedure is that of Soxhlet, as modified by Fleischmann (*Lehrbüch der Milchwirtschaft*, 4th edition, 1907).

"Five c.c. of the rennet solution are made up to 100 c.c. with distilled water, and well mixed. 10 c.c. of this dilution are blown forcibly from a pipette into 500 c.c. normal fresh milk, at a temperature of 35° C. and the exact time to a second noted when the two liquids are brought together. The length of time which elapses before coagulation is apparent is noted. The strength of the rennet solution is then calculated according to the formula $x = \frac{40p}{t}$ where x = the quantity of milk which would be curdled in 40 minutes at the same temperature by a similar quantity of rennet, p = the proportion between the rennet and the milk, and t = the time in minutes." For good results p should be 1000 (or multiple of it), and t, between 2 and 5 minutes. To maintain an even temperature during the period of coagulation is a difficult matter. In standardising rennets, when considerable accuracy is demanded, a special apparatus, such as that elaborated by the author, should be used (see illustration). Water at a constant temperature (95° F.) is supplied from Pulfrich's circulator (see *Zeitschrift für Instrumentenkunde*, Jan., 1898) to the jacket of a specially constructed glass cylinder, through the base of which passes a glass tube drawn to a fine point. The cylinder is provided with a lid. One litre of milk at 95° F. is additioned with 10 c.c. of a 10 per cent. dilution of the rennet to be tested, and immediately poured into the glass cylinder. The milk will run out in a fine stream through the glass tube. Immediately coagulation takes place, however, the capillary point of the dropping-tube becomes stopped up, and dropping ceases. The time from the addition of the rennet until coagulation (as determined in this way) is apparent is carefully registered by a stop-watch.

The great drawback to this test is the difficulty of securing milk which will give a uniform test from day to day. Even when care is taken to have the milk at the same acidity and temperature each day, considerable variation will be found in the time of coagulation for the same rennet. This is due partly to small variation in the ash constituents, partly to variation in the

hydrogen ion concentration, but mainly to the biochemical condition of the milk. It is a well-established fact that, for several hours after it has been produced, fresh milk has an anti-rennin action, the strength of which varies from day to day. This reaction gradually weakens and disappears, so that, by the fifth hour, its effect is small and almost negligible. Sometimes, however, it persists considerably longer, especially with milk of cows suffering from inflamed udders. If, then, perfectly fresh new milk is used, a uniform test cannot be got.



Apparatus for supplying water at a constant temperature to the jacket of a specially-constructed cylinder, which is provided with a fine tube through its base, and covered with a lid. The milk, at the proper temperature, is additioned with the rennet, and poured into the vessel A. Immediately coagulation takes place the capillary point of the dropping-tube becomes stopped up and dropping ceases. The time to reach this stage is carefully registered.

VESSEL A.

What is required is a standard milk. To procure this, a modification of Vandervelde's method may be resorted to. This consists in testing fresh separated milk of the same origin for several days in succession. The cows producing the milk must be normal, and above all, have sound udders. When the same "rennet test," with a control rennet (such as Hansen's) has been got for two or three days in succession, the milk at 20° acid is preserved with an iodoform-ketone solution (made by dissolving 3 per cent. by volume iodoform in acetone, and using 3·3 c.c. for every 25 c.c. milk). This preserves the milk from bacterial fermentation, and at the same time has no effect on the rennin enzyme. Milk prepared in this way can be kept for several weeks without change.

Employing this modification of Soxhlet's method, the rennet may be drawn off from the extracting vat when it reaches a strength of 1 in 10,000.

Clearing Rennet Solutions.

As soon as the rennet is decanted off, it is advisable to add more salt. An addition of 4-5 per cent. is indicated. This adds to the keeping properties of the extract.

The primary extraction is invariably muddy in appearance, and contains in solution varying qualities of mucus. Unless this turbidity is removed, the rennet will rapidly lose strength, and will be more liable to bacterial fermentation. To clear the extract without much loss of enzyme, is the most difficult problem in rennet-making. Three methods are open to practice :—(1) direct filtration; (2) employment of clarifying agents; (3) precipitation and sedimentation.

Direct Filtration.

Provided that the filter is sufficiently close, direct filtration will give a clear solution. But, on account of the nature of the suspended material, the pores of the filter soon become choked up. The mucus forms a fine surface film, which acts as a barrier, and renders the filter impermeable at ordinary pressures. If increased pressure be employed to force the solution through, the greater part of the enzyme is retained by the mucus layer on the filter. At best, filtering turbid rennet under pressure through a close-grained filter, is slow and tedious; and ultimately a stage is reached at which no filtration is possible, at least with pressures up to 30 lbs. per square inch.

A graded filter is rather more successful than an ordinary simple close-grained filter. Such may be constructed of successive layers of sand of varying grades of fineness, the lowest layer being of fine glass sand. This filter possesses the advantage that it can be washed when it shows signs of becoming blocked up, by forcing water through it in the reverse direction. But this filter is rather slow, and sometimes a good deal of the enzyme is held on the filter by adsorption.

Charcoal filters give a fine clear filtrate, but they adsorb practically the whole of the enzyme, and are therefore useless in rennet making.

Certain kinds of filter-pulp will give a clear solution, and if the filter mass be properly built up on the filter plate of a Buchner funnel, a fairly rapid filtration will result with moderate pressure. The rennet extract, however, may lose 20–30 per cent. of its strength in the filtration process (see illus.).

A prepared filter was found much more satisfactory in giving a clear solution, without much loss of enzyme. Using a Chardin filter paper, coated with a thin glycerine albumin solution lightly acidified with dilute HCl, the loss of ferment by adsorption, may be reduced by at least 10 per cent. The filtration, however, is slow.

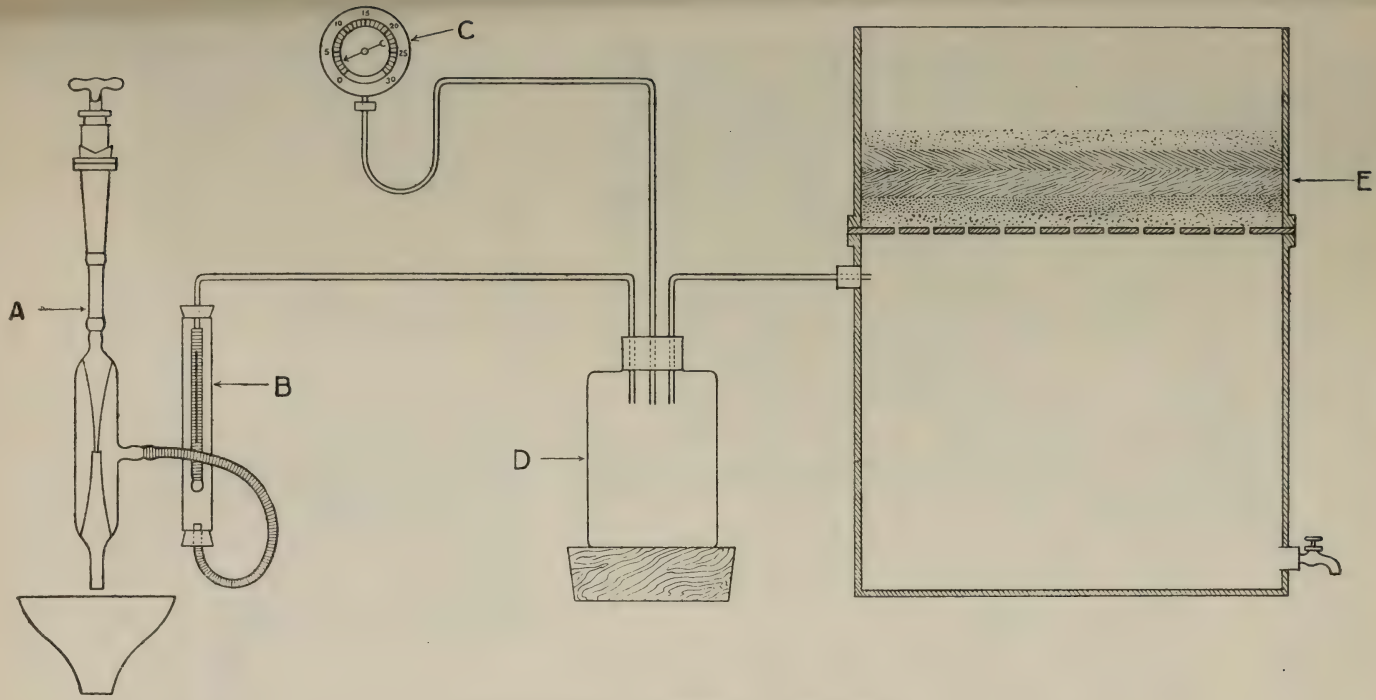
Asbestos wool, chamois leather, felt cloth, and most hardened filter papers are not satisfactory filtering agents. They are much too slow, even when pressure is used, and quickly become blocked up with slime.

Cotton-wool as a filter is of little service. Turkish towelling or Hessian fibre may be used when operating on a large scale. These filters wlll prove quite successful if the filter is properly constructed.

Filter presses are used by manufacturers, but special filter cloths and plates are required. Kieselguhr plates and nitrated fabric filter cloths may be used in these presses.

Berkefeld filters and Pasteur-Chamberland candles and similar earthenware filters adsorb the enzyme *par excellence*. They become quickly stopped up. Filters of this type produce a bacterial free rennet—this is their chief recommendation.

Attempts have been made to diminish the adsorbing powers of filters without impairing their efficiency; but, hitherto, only a moderate degree of success has attended these efforts. According



COMPOUND SUCTION FILTER.

A Bunsen Pump. B Vacuum Trap. C Pressure Gauge.
D Trap for Liquid. E Combination Vacuum Filter (showing layers of filtering material).

to Jahnson Blohm, cholesterol prevents the inactivation of rennin by inhibitory substances like charcoal (*Z. Physiol. Chem*, **82**, 178). The same applies to adsorbent filters.

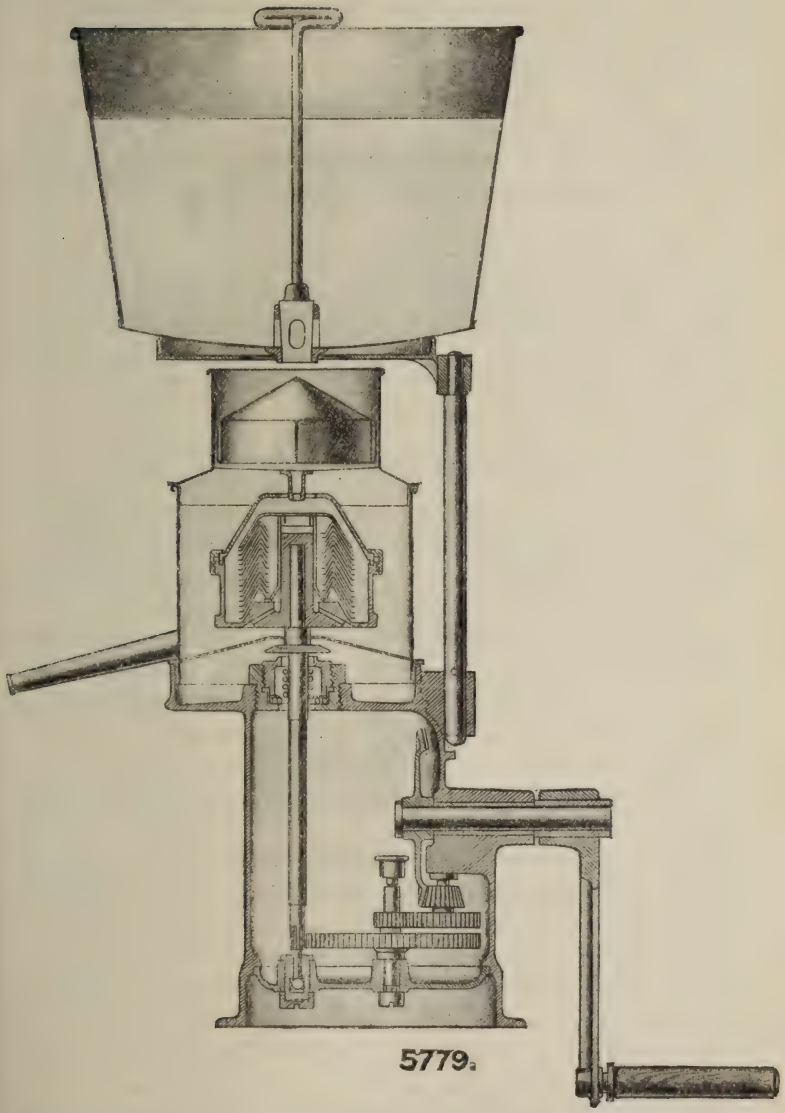
Use of Clarifying Agents.

After an extended trial, we cannot recommend the employment of clarifying agents. To be useful, the particles must be finely divided ; but, if much mucus is present, such particles, unless of great density, will simply be held in suspension by the liquid, and even prolonged sedimentation will not clear the solution entirely. Kaolin, gypsum, kieselguhr, talc, and animal charcoal are only slightly effective in clarifying the extract ; they remove a good deal of the enzyme, especially the charcoal. Colloidal silica may be given a trial when the rennet is only faintly turbid. Fine wood pulp or paper pulp shaken up with the rennet extract and allowed to sediment will clear the solution considerably, but some considerable part of the ferment is removed. In this case, however, the enzyme may be recovered by re-extraction of the sedimented mass. Mechanical clarification is more helpful. If the freshly extracted rennet solution be passed several times through an ordinary separator, or better, through a specially modified centrifugal (called a clarifier), a considerable amount of the suspended material will be removed (see illus.) Indeed whatever process of clearing be restored, a preliminary centrifuging should be given.

Precipitation and Sedimentation.

This is most effective when a suitable precipitant is used, and when the precipitate obtained is not too flocculent or gelatinous. Some precipitating agents have a deleterious effect on the enzyme, *e.g.*, aluminium silicate ; many remove it from solution and cannot therefore be employed in the preparation of liquid rennets. For instance, sodium phosphate, added to a solution containing calcium chloride, brings down most of the rennet ferment. (This process is used in the preparation of rennet powders.) A saturated salt solution will act in a similar manner. Alkalis will precipitate out the mucus, but they destroy the ferment, if left in contact with it even for a short time. If these are tried the resultant clear solution should be at once neutralised.

CLARIFIER.



PATENT CENTRIFUGAL MACHINE FOR CLARIFYING TURBID LIQUIDS.

—Made by WATSON, LAIDLAW, & Co., Glasgow, S.

Tannic acid dissolved in glycerine and added direct, without dilution, has given good results on a laboratory scale; little enzyme appears to be lost.

Dilute acetic acid is also very useful in precipitating out the mucous matter. Care should be taken to add no more than will give the necessary precipitate. It is better to add it at intervals in successive small quantities until the precipitate appears. Several hours may elapse before it forms. The free acid should subsequently be neutralised.

Alcohol has been employed as a rennet preservative; it may also be used as a clarifier. Enough only should be added to produce a light precipitate. Generally, alcoholic rennet solutions are liable to considerable loss of strength, and do not remain active for long.

Activating Rennet Solutions.

The coagulating power of a freshly-prepared rennet solution can often be considerably increased by the addition of activators. Certain acids and salts have a well-defined effect in this direction. Of the acids, hydrochloric acid up to concentrations of ·15°/₀ – ·2°/₀ increases the activity of the enzyme. Lactic acid, acetic acid, and sulphuric acid, and, in a special degree, phosphoric acid, behave in a similar manner. Saccharin in feeble doses activates the enzyme, but acts as a retarder in large amoumts. The acid activators probably act by liberating enzyme from the pro-enzyme in the solution. Lecethin has a favourable effect on the enzyme.

Among the salts which accelerate the coagulation of milk by rennet are Barium Nitrate, the chlorides of Barium, Calcium, Strontium, Aluminium, Magnesium, and Zinc. These salts are said to act mainly by liberating acid in the milk, which in turn stimulates rennet coagulation, but some have a direct effect on the rennet itself.

Activated rennet solutions do not, as a rule, maintain their activity for long when an acid is the activating agent. On storage they lose strength. Salts are more successful in this respect, especially calcium salts. Acid potassium phosphate in small amounts exercises a stimulating and preservative effect on the enzyme.

Rennet is very sensitive to alkalis; caustic alkalis, even in feeble doses, paralyse the enzyme.

Catalyst poisons destroy the ferment.

Colouring Rennet Solutions.

After clarification, the primary extraction of cured vells possesses naturally a brownish colour, the intensity of which depends on the age of the vells and the manner of curing. Second extractions are usually colourless.

Commercial rennets are usually artificially coloured, partly to give them a distinctive appearance and a uniform shade, but mainly for protective purposes. It is a well-established fact that certain rays of light (the ultra violet rays) inactivate rennet, either under aerobic or anaerobic conditions; visible rays are without effect on it. A colourless rennet solution exposed to bright sunlight quickly loses its proteolytic properties. The use of a colouring agent is designed to act as a barrier to these harmful rays.

Caramel may be used; but, if added direct to a rennet extract containing salt, it precipitates out, and in doing so removes most of the enzyme. Hence, before using, the caramel should be dissolved in a salt solution rendered faintly acid and filtered.

Cochineal and, occasionally, saffron are used. Annatto and turmeric have been tried. Bismark brown is useful.

Loss of Activity.

Rennet solutions invariably undergo degradation on keeping. The loss of activity is greatest in the period following extraction. After the lapse of 3 months the rate of loss is very much lower, and from now till the end of the first 12 months, the rennet is nearly constant in strength. Generally speaking, the loss is 20 per cent. for the first year and about 5 per cent. annually thereafter. Most rennet manufacturers, in consequence, aim at an initial strength of 1 in 12,000, so that when the rennet is put on the market, it will have a fairly uniform strength of 1 in 10,000.

The loss of strength is difficult to understand, and no satisfactory explanation has yet been offered to account for it. Probably the loss falls on the pepsin, rather than on the chymosin content of the solution.

The mode of extraction and the clearness of the solutions are factors which appear to influence the rate of loss. Clearness of solution, however, will not in itself prevent loss of strength. Oil or mustard in very small amounts appears to have some effect in delaying the loss of ferment and in maintaining longer the activity of rennet solutions. What the rennet maker seeks after is a permanent activator. So far, such does not appear to have been found.

Storing Rennet.

Rennet should always be kept in a cool store and in well-corked jars. Temperatures over 70° F. have a weakening effect on rennets, especially if the extract is not very strong and if the salt concentration is low. Exposure to air induces mould growth and turbidity and results in a loss of activity.

Commercial rennet is marketed in oaken kegs, or in tins coated internally with paraffin wax. If sold in bottles, the bottles should be coloured so as to exclude the injurious light-rays.

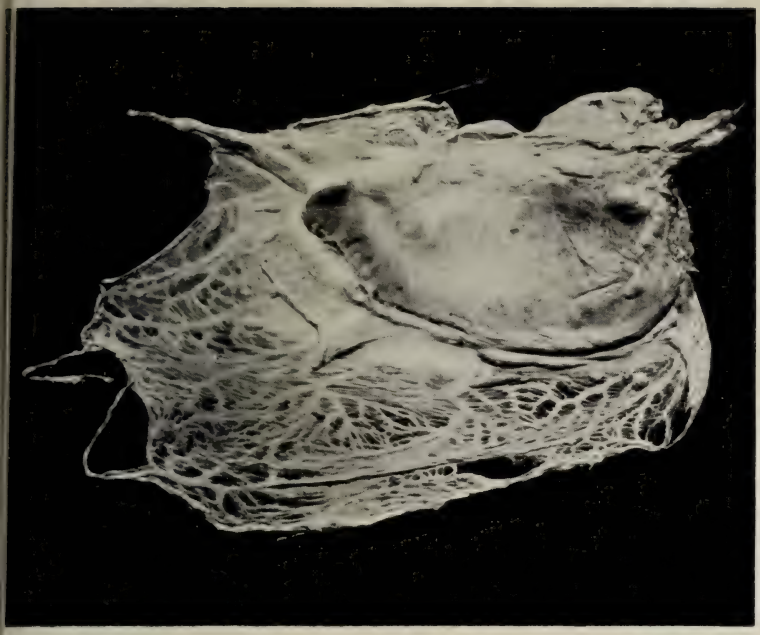


Fig. 1.—Fresh Stomach (Vell), with attached tissues.

Fig. 2.—Vell, with adhering mesenteric membranes.

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Fig. 3.—Knives used in trimming Vells.

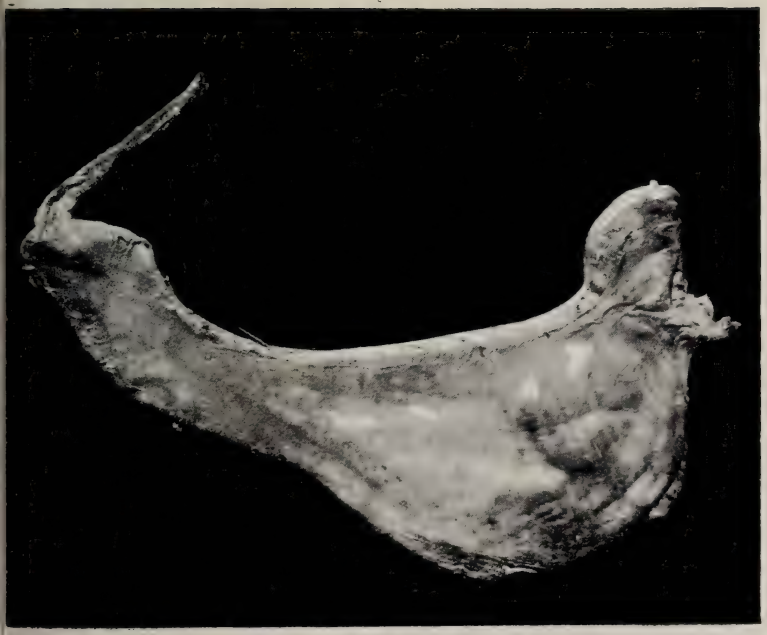

Fig. 4.—Vell cleaned and trimmed.

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g5.—Vells inflated and dried; showing external salt encrustation and, internally, olds of mucous membrane in which the rennet-producing cells are located.

Fig. 6.—Vells dried, deflated, and cured; ready for extraction.

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Bulletin No. 93.

The West of Scotland Agricultural College.

The Production of Honey

BY

JOSEPH TINSLEY, B.B K.A. (First Class),

Lecturer in Bee-keeping.

Glasgow :
Printed by Robert Anderson, 142 West Nile Street.

1919.

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THE PRODUCTION OF HONEY.

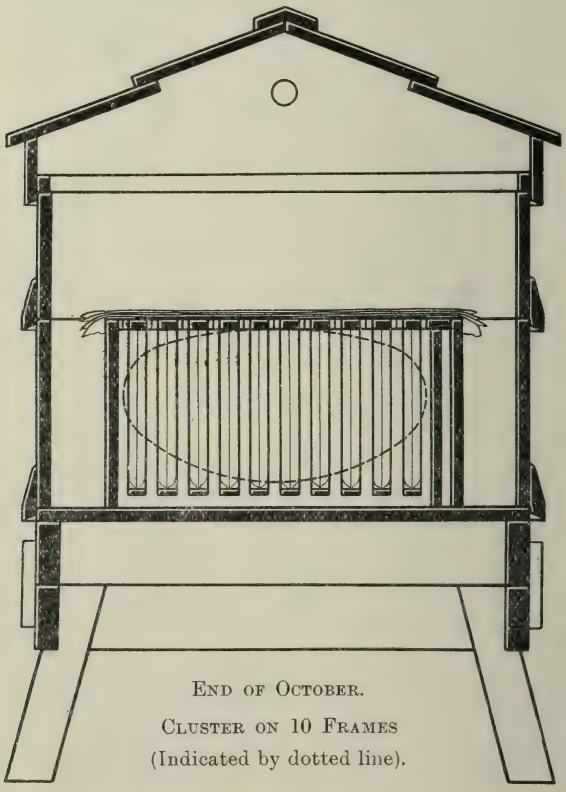
THE sources from which bees derive honey are many and varied. Practically all flowers which have nectar-glands provide the raw material out of which bees elaborate honey. The term "flowers" includes the floral shoots of trees and shrubs as well as herbs, with which the term "flower" is more commonly associated. Throughout the growing season there is a regular succession of flowers which are visited assiduously by bees. The earliest are those of the sycamore, hawthorn, pear, plum, &c. Each of these produce a honey which varies in bouquet and density. But the two main sources from which bees collect nectar are white clover and heather; probably 90 per cent. of the season's honey is obtained from these flowers. The aroma and flavour of clover honey is quite distinctive from that of heather honey; the latter is a "strong" honey, and has for long been associated with the "Athol brose" of song and story. But only in certain selected districts does one find clover and heather growing in profusion. The period when the main nectar flow is in evidence varies according to the nature of the season. The bee-keeper, by making himself acquainted with the flora in his environs, will be better able to determine the period during which the maximum storage of honey by the bees is possible. Now, as the main honey flow, either in hill or dale, is generally of short duration, it will be apparent that the output of the apiary will be dependent on the strength of the colonies at this critical epoch. The only really productive and valuable stocks are those which can send forth a force of several thousand workers at the time when the fields are redolent with fragrant flowers; and, in so far as the bee-keeper can have his colonies populous and vigorous at this stage, he can command success.

In those districts where clover is the chief source of the honey yield, the bee-keeper should aim exclusively at the production of extracted or liquid honey.

Comb honey in sections is still favoured by some bee-keepers, but experience has shown that fully 50 per cent. more honey can be produced from a colony working for "extracted" honey than "comb" honey. The profit from "extracted" honey is also greater, because the combs after extractiou are retained for further service, while sections of comb honey are sold in their entirety.

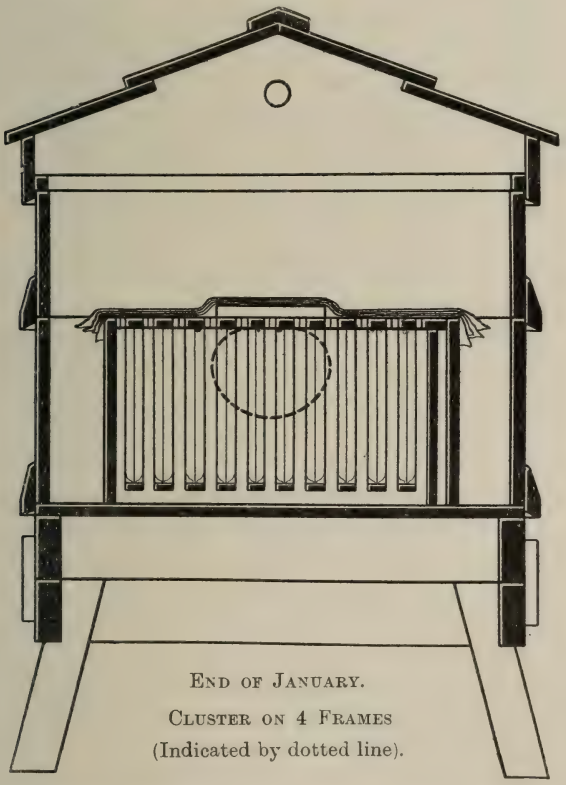
Winter Management.

During the winter bees hibernate. They usually crowd together on the combs, forming a cluster of globular shape. If this cluster be observed in late autumn, it will be seen to extend in diameter right across the hive; but, as winter approaches, its dimensions grow smaller and smaller. If, at



End of October.
Cluster on 10 Frames
(Indicated by dotted line).

the beginning of the hibernating stage ten frames were covered by the bees, towards the end of November six to eight would be occupied. The reduction in space occupied by the bees is brought about partly by the cold weather, which causes the bees to cluster more closely for warmth, and partly by the normal death-rate of the hive. During the greater part of the winter the queen lays no eggs, and, consequently, no new bees emerge to take the places of those dying from senile decay.



End of January.
Cluster on 4 Frames
(Indicated by dotted line).

Towards the middle of January the queen deposits her first batch of eggs. The actual numbers laid—which, generally speaking, are relatively small—will be regulated by the size of the cluster, the state of the food supply, and, to a great extent, by

the weather conditions. If mild weather prevails at this time, and the stores of food are ample, the queen will increase the number of eggs daily. These eggs are incubated by the warmth from the cluster and, in the course of three weeks, the young bees emerge from the cells, and take their share in the work of the colony. The cluster, therefore, begins to increase in size, and, from now onward, the colony will receive a continued accession of strength.

During the first three months of the year, while this regeneration of the hive is taking place, the bee-keeper must see to it that the colony does not lack the necessary food supply. By failing to observe this simple precaution beginners in bee-keeping often lose their colonies. The bees perish through sheer starvation. Consequently the reserves of food should be ample in the autumn before the hibernation stage is reached.

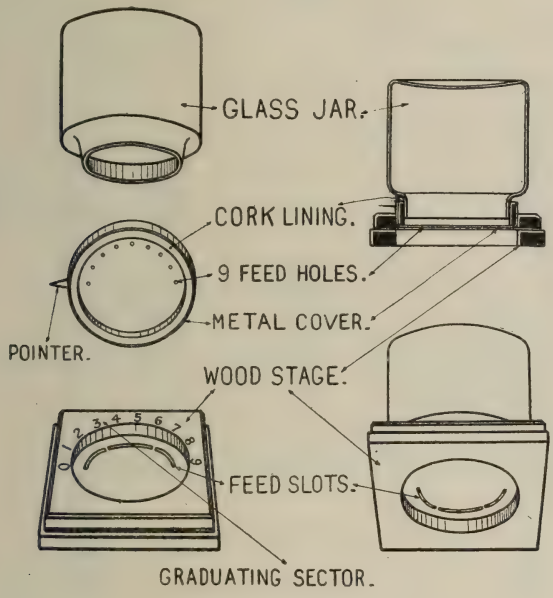
Spring Working.

The first inspection of a colony of bees is made in the early spring—usually about the middle of April. In proceeding to ascertain the food supply the operator should take advantage of a mild day, and, in making the examination, should subject the bees to the minimum of disturbance. The examination, which will take place preferably about noon, should be brief and thorough ; prolonged exposure will result in the temperature of the hive being lowered and in the brood being chilled. The actual condition of the colony relative to the work of the queen, the state of the food supply, and the number of frames covered by the bees, should be noted on a card, which for convenience is nailed inside the roof of the hive.

Evidence of the queen's activity will be found in the shape of brood in various stages ; hence it is not necessary to hunt over all the frames to ascertain her presence.

The food supply if short will require replenishing. Pure cane sugar made into syrup (5 lbs. sugar to $3\frac{1}{2}$ pints of water) should be given. Generally speaking $\frac{1}{2}$ pint daily should be ample, even for a prosperous colony. Many beginners make the mistake of being over-generous at this stage. The result

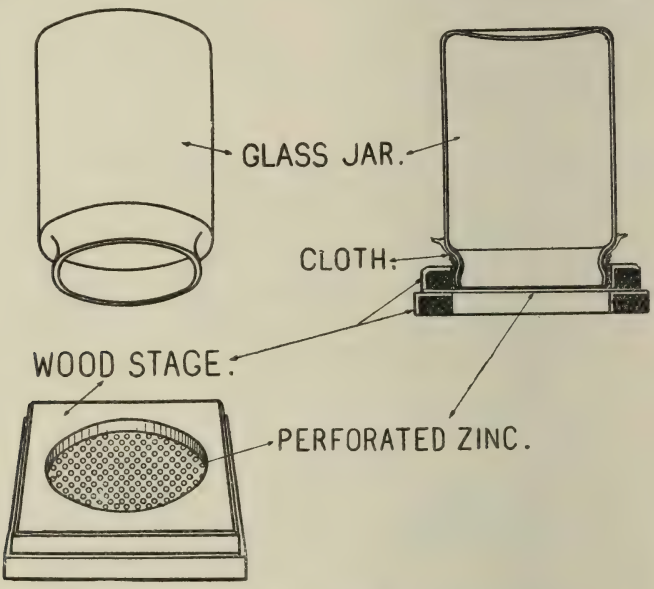
is that a number of cells are filled with syrup which would otherwise be reserved for brood. To regulate this supply of sugar syrup, a bottle feeder should be employed.



Graduated Feeder.

A simple and effective automatic feeder may be made from an ordinary 2-lb. glass jar. This is filled with syrup, the mouth covered over with a piece of coarse cloth tied with string, and the jar inserted, mouth downwards, over the cluster of bees. The "feed-hole" is usually in the centre of the hive where the bees generally cluster. The syrup as it oozes slowly out is utilised by the bees. The jar when requiring to be refilled is removed from the "feed-hole," which is covered by a piece of wire gauze or perforated zinc.

The feeding of syrup should be carried on until nectar is collected in sufficient quantities to feed the adult bees and the brood.

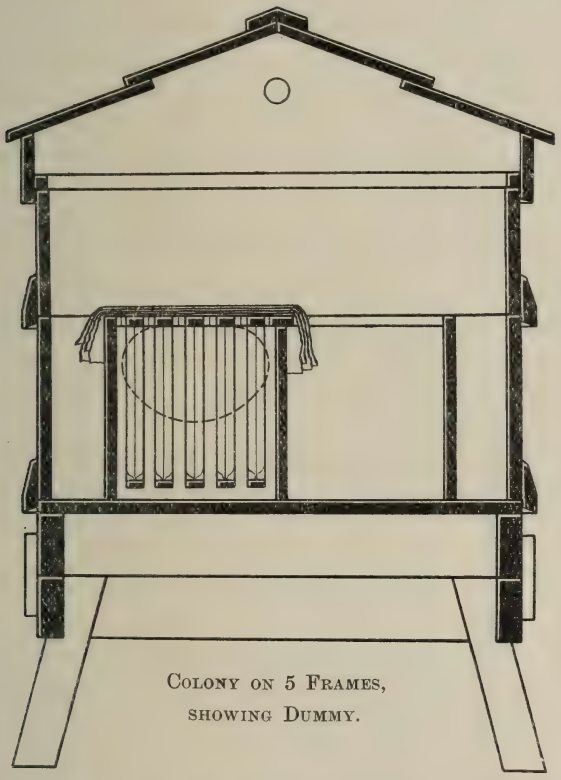


Bottle Feeder.

If the spring examination shows that ample food supplies are present, there will be no necessity to feed this liquid syrup; but, in order to stimulate the activity of the colony, some of the sealed cells should be cut or bruised. Instead of re-sealing over this uncapped honey, the bees transfer it to neighbouring cells. The activity of the colony thus being aroused the production of brood naturally follows.

The number of frames covered by the bees will vary according to the condition of each stock and to the season. An important point in the spring management is to see that no more frames are left in the brood-chamber than the bees actually cover. If ten combs were allotted to a colony in the late autumn and only five of these were occupied by the cluster, the bees would be compelled to heat the whole chamber, instead of the space

actually occupied by the colony. To maintain this temperature means excessive expenditure of energy on the part of the bees and the consumption of abnormal stores. To obviate the wastage of bee life and of food, only as many frames should be left in



COLONY ON 5 FRAMES, SHOWING DUMMY.

the brood-chamber as are actually covered by the bees. The unoccupied frames should be removed. The dummy or follower will close up the frames. This plan will conserve the heat of the hive.

With the advent of warmer weather, and the consequent increase in the population of the hive, the frames can be returned as required, giving one frame at a time until the brood-chamber again has its full complement. If the combs

which were removed are old or clogged with pollen they should be discarded altogether, and their places taken by new frames fitted with sheets of foundation and properly wired. Old combs clogged with honey and pollen will not provide a sufficiency of worker cells required by a prolific queen, and will thereby put a limit to the rapid increase of a colony. If a frame fitted with foundation or an empty comb is to be added now, it should be inserted in front of the dummy and not in the centre of the brood-chamber, because when the colony is divided in this way, there is great danger of the brood becoming chilled owing to the vagaries of our climate.

Minor Honey Flows.

It usually happens that in the majority of districts the main flow of honey is preceded by light flows from the fruit-blossoms, sycamore, hawthorn, &c. These flows are of short duration, and it is scarcely advisable to attempt to harvest such crops. It is far better to allow these minor flows to act as an impulse for further energy on the part of the queen, and allow the nectar to be used for brood rearing. This can be accomplished by a process called "doubling."

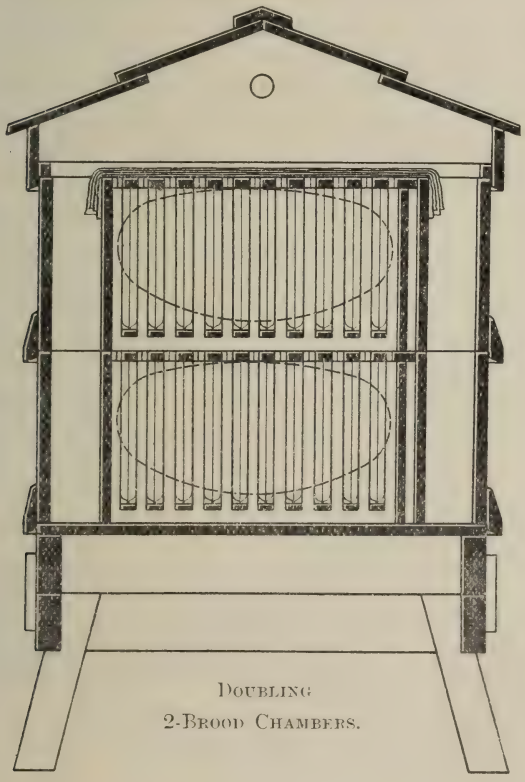
Summer Operations.

Doubling.

This is a method of securing a rapid increase in the population of the hive, or, more generally speaking, of doubling its numbers. This is effected by superimposing an additional brood-chamber, complete with frames containing foundation or already built combs over the original brood-chamber of the hive. The queen is then allowed access to both brood-chambers; and, if she is prolific, she will quickly fill both sets of combs with her progeny. Not only does this device save time in increasing the tenantry of the hive, but it will also largely prevent swarming—which is usually attributed to the limited space in a hive with only one brood-chamber.

It is important that the operation of doubling be undertaken at the right time. Generally speaking, a colony should be in

condition for this work early in May. The aim of the bee-keeper should be to have the whole of the twenty frames occupied by brood, in all stages of development, about three weeks before the advent of the main nectar flow, which, in the south west of Scotland, commences with the flowering of the clover in the latter part of June. About the second or third week in June the queen should be sought for and placed in the original brood-chamber, and a queen-excluder inserted between the two compartments. The object of thus confining the queen is to prevent an over-production of brood. The brood in the top chamber will be hatching each day; the cells vacated by the fully-developed bees will in time be filled with nectar, so that the top brood-chamber can be utilised as an extracting super.



Doubling 2-Brood Chambers.

It will, of course, be necessary to provide a shallow box of frames over the upper brood-chamber, in order to provide accommodation for the increasing number of bees hatching from the brood-combs in the upper chamber, and at the same time to make provision for the storage of nectar.

If the queen were not excluded from the top chamber in the manner described, each cell as it became vacant through the young bee hatching would again be used for brood purposes, with the result that there would be an exceedingly large mass of brood to support. This could only be done at the expense of honey, and the only honey it is advisable to sacrifice is the early flow.

It will be obvious, of course, that only specially-constructed hives, such as those built on the "W.B.C." principle, can be used for doubling. A modification of this method consists in employing a shallow frame-box, instead of a brood-chamber. These frames must be fitted with sheets of "worker" foundation, and the "W.B.C." ends should be used for spacing purposes, on the same lines as brood-frames, otherwise an excess of drones will be raised.

If the process of doubling as described above be carefully carried out, a largely increased yield of honey from each colony may be confidently anticipated. Our experiments at Kilmarnock show it to be by far the most satisfactory procedure. One colony doubled in this manner gave a yield of 167 lbs. honey (extracted); in addition 35 lbs. were left in the hive for wintering purposes.

But it is only with very prolific queens that the bee-keeper can work along these lines. To ensure the presence of such the bee-keeper may either attempt to breed a prolific strain of queens himself—and this requires special knowledge—or purchase them from a reliable dealer.

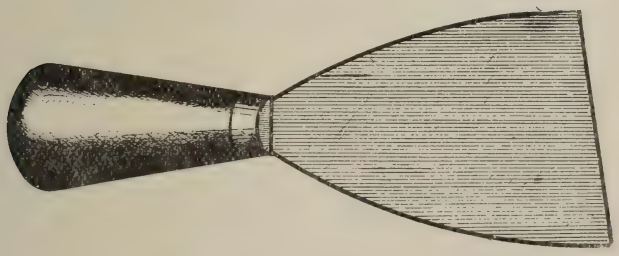
Uniting.

Colonies of bees which are not populous enough to cover more than ten frames within a week, or ten days of the main honey flow, are not capable of being doubled; but considerable advantage may be gained by combining two colonies into one, after the same manner as doubling. It has been found by experience that

two medium colonies working singly will collect less honey than if united into one stock. The explanation of this is that more bees are liberated for the field. When two distinct brood-chambers demand attention a large proportion of the population is retained in each hive to attend to brood rearing. The union of two colonies liberate at least 25 per cent. more bees to gather the nectar.

Placing on Supers.

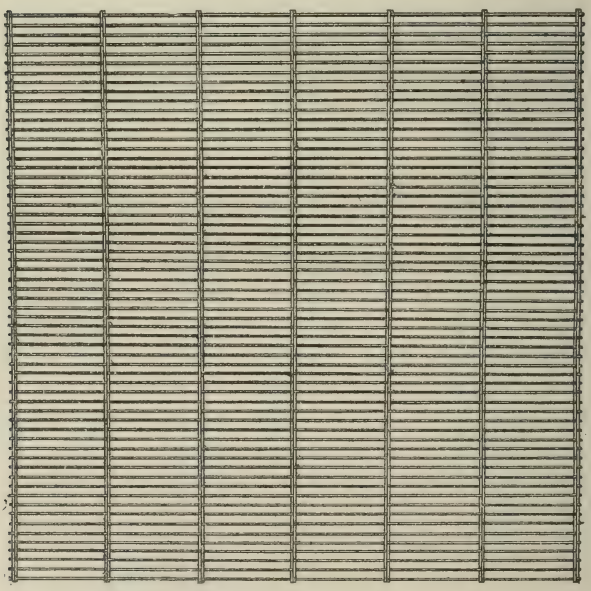
If for any reason doubling is impracticable or unadvisable, and uniting is not attempted, the bee-keeper should so manage his bee colonies that, prior to the honey flow, the brood occupies nine or ten combs with seams of bees between each frame. Nothing is to be gained by making provision for the storage of honey before the colony has sufficient numbers to cover the whole of the brood-frames. If supers are added before the brood-chamber is complete, the enlarged space requires to be heated, and this imposes a severe strain on the activity of the bees. In addition, greater food is consumed to maintain the temperature of the hive. Supering too early, then, retards the development of the colony and weakens the stock at a very critical time. But as soon as conditions are favourable and the brood-chamber is teeming with bees, preparations should be made for supering the hive. The proper time to add the supers is just at the stage when the storage of nectar has commenced. Evidence of this is to be found in the appearance of small pieces of white wax on the tops of the brood-frames, and in the gradual elongation of the cells along the top row of the brood-cells. When this condition is observed the tops of the brood-frames should be cleaned with a scraper knife.



Scraper Knife.

The removal of the "brace combs," *i.e.*, brood-frames with wax adhering on their tops, will permit of the queen-excluder resting evenly over the frames, and in working for extracting honey a queen-excluder is essential. Four strips of cloth laid evenly along the tops of the combs will occupy the space which the excluder does not adequately cover, and thereby obviate any loss of heat after the super is given.

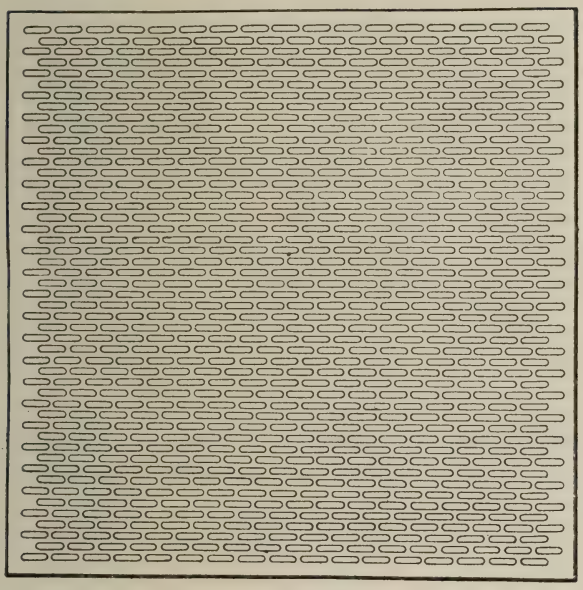
Two types of excluders are in common use, the zinc and the wire pattern. The latter is the better type, since bees gain easier access through the spaces.



The "Whyte" Wire Excluder.

The excluder having been placed in position, the super is inserted on the hive. Over it should be placed, first a calico cloth, and then warm quilting, or what is equally effective, clean

sugar bags. This is done to conserve the heat, for bees will rarely enter cold and draughty supers.



Zinc Excluder.

Nectar and Honey.

It should be observed that bees do not collect honey, but nectar. Under this term are included odoriferous (generally sweet) and sapid juices secreted by special organs of the flower, called the "nectaries." The transformation of nectar into honey is brought about somewhat as follows. The nectar is first removed from the nectaries by the *lingua* or tongue, and transferred to the honey stomach, when certain chemical changes

take place. It is regurgitated and passed along the tongue into the cells. Nectar when first collected contains a large amount of moisture, but the bees, by raising the temperature of the hive, bring about the necessary evaporation of the water. Each cell containing the finished product (honey) is then sealed over by the bees with a waxen covering. When the combs in a super are filled and sealing of the cells has commenced it is time to give another super. The filled super should be raised and its place taken by a fresh super inserted underneath—that is, next to the brood-chamber. If this is done, the bees to reach the new super will not have to travel over that nearly completed. Time and energy will thus be saved. A third super, if required, should be given in the same way.

Honey matures better if left on the hive for some time after it is sealed. It may be left until the main honey flow is over.

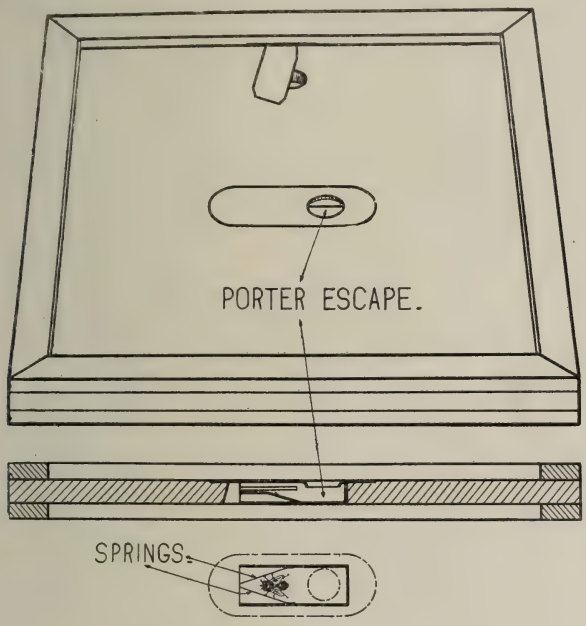
Removing Supers of Honey.

Combs when filled with honey and ready for removal may be freed from bees by the aid of a soft brush or by shaking each one in front of the hive. In either case a good deal of smoke must be used to subdue the bees. This smoke may impart an undesirable flavour to the honey. Such methods, although favoured by many bee-keepers, besides being clumsy, tend to encourage robbing, as during the brushing or the shaking of the combs, honey is spilled, and this attracts bees from neighbouring colonies to prey upon each other's stores.

Much better results can be obtained by using a "Porter Bee Escape." If this device is placed underneath a completed super in the middle of a warm day, the super will be free of bees by the following morning. In construction this bee escape consists of a board of the same size as the honey super. At its centre is a hole through which bees can emerge. When once they pass through this outlet they cannot re-enter the chamber, being prevented from doing so by two fine wires placed in the hole which almost come to a point. By the use of this contrivance there is a minimum of excitement, and robbing is not encouraged.

Extraction of Honey.

Supers of honey when removed from the hive should be taken to a warm, dry room, which must be bee-proof. A period of storage prior to extraction is not advocated, for it will be found

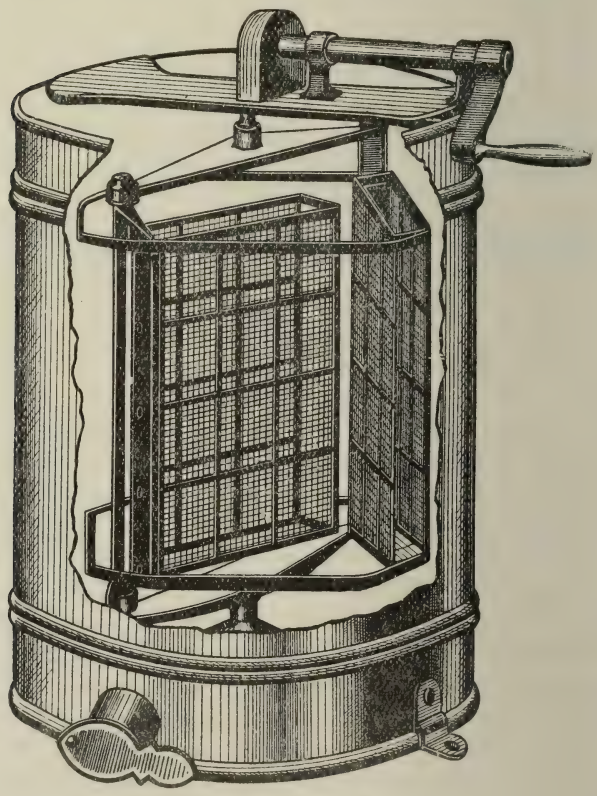


SUPER CLEARER.

that honey can be extracted from the combs much more easily, if the operation is undertaken immediately, than if the supers are stored for some days prior to extraction. The reason for this is that the honey is warm and more fluid when fresh from the hive. When allowed to stand over for a few days it cools and becomes more viscous.

Prior to extraction the honey should be graded. Combs should be sorted out, placing them in three groups to correspond with the three grades of honey, viz:—light, medium, and dark coloured honey. By holding a comb to a strong light it is easy to decide the class of honey contained in the comb. The light honey should be extracted first; medium honey second; and lastly, the dark coloured honey.

Honey extractions are simply modified centrifugals which, when in operation, expel the honey from the combs by the generation of centrifugal force. A honey extractor consists of a large drum with a central axis which is caused to rotate by gear wheels. To this central revolving axis are attached radial arms carrying the cages for holding the combs. Extractors are constructed to accommodate 2, 4, and 6 frames at a time. Perhaps the most serviceable type is that which operates on the "Cowan" principle. This extractor holds two frames, and will generally be found to be the most serviceable, either for a small or a large apiary.



"Cowan" Extractor.

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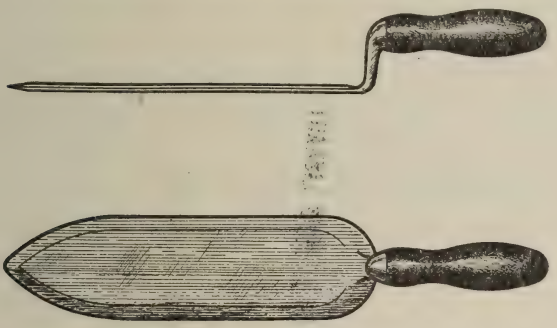
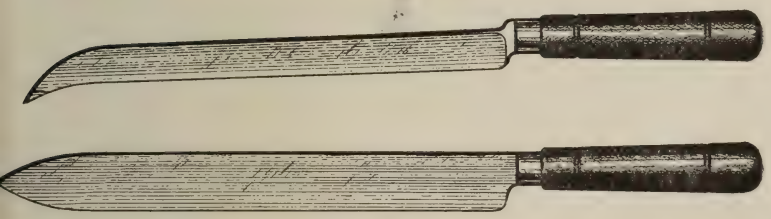
The honey extractor should stand perfectly level, and should be rigidly fixed down to the floor.

To prepare the combs for extraction one should proceed as follows:—Hold the comb firmly by the left hand, and using a sharp knife (previously dipped in hot water, then dried) cut the caps of the cells, starting from the bottom and working upwards. A light saw motion should be given to the knife as the pressure demanded by a direct cut or slice will surely damage newly-built combs. In making the cut, the comb should be tilted so that the cappings will fall clear of the honey. The comb is then reversed and the other side cut in a similar manner.



"Bingham" Uncapping Knife.



"W. B. C." Uncapping Knives.

The two combs when placed in the extractor should be as nearly equal in weight as possible. The machine will then run very smoothly. If a thin and a thick comb be extracted at the

same time, the necessary equipoise will be absent, and one of the combs will almost certainly be broken during the centrifugalisation.

When a sufficient number of frames have been extracted, the honey is drawn off and strained. In sieving the honey, it is advisible to use a piece of cheese cloth over the top of the ordinary gauze strainer. This will remove any particles of wax which have arisen through the cutting of the comb.

Honey after extraction should stand in the receptacle into which it is strained for at least 48 hours. The air bubbles will rise to the surface and thereby assist in clarifying the honey. It may then be run into bottles or cans as desired.

The combs after extraction should be returned to the hive. The bees will rapidly clean out any honey remaining in the cells. These extracted combs should be given back to the colonies towards evening, when the bees have finished flying for the day. The bees will quickly clean out any honey that the extractor has failed to remove. The combs when "dried" are removed from the hive and stored away in a warm room for another year.

BULLETIN No. 94

West of Scotland Agricultural College

A Common Disease of Potatoes

Viz., Stem Rot, Rosette or Little Potato

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Notes on the Fungus Rhizoctonia, with special reference to the Disease which it causes on Potatoes, viz., Stem Rot, Rosette or Little Potato.

For a long time it has been known that species of the common fungus Rhizoctonia are parasitic upon a number of plants, and that they frequently cause "damping off" of young seedlings. Among the plants upon which they have been found as parasites are beet, sugar beet, charlock, cabbage, cauliflower, turnip, lettuce, cress, tomato, tobacco, bean, pea, parsnip, radish, rhubarb, raspberry, blackberry, potato, red clover, lucerne, and many different floricultural plants.

This article is concerned with the disease which Rhizoctonia sets up in the potato. It is in this crop that the disease is most prevalent and causes the greatest damage. The reason is that, owing to the method by which the potato is propagated, the fungus finds a very favourable opportunity for spreading.

At least two species of Rhizoctonia are known to attack the potato—namely, *R. solani*, Kühn, and *R. crocorum* (Pers.) DC., or *violacea*. Of these the first is said to be the more common, although from observation among potatoes in the West of Scotland the second species occurs quite as frequently as the first.

Until quite recently it was thought that these two fungi caused no serious loss to the potato grower, but it has now been convincingly shown that the economic loss caused by species of Rhizoctonia in America, and also in Europe, is so great that the disease must be considered one of the most important potato diseases.

It was about two years ago that the widespread distribution of this disease was noted by the writer in Scotland. Reference to literature shows that the disease is mentioned by Pethybridge in 1910 as occurring in Ireland, and further, that it was observed by Güssow in 1905 in England. Yet although the disease was little known to the scientific investigator until recently, from inquiry it seems that some

observant farmers know of this plague, although unaware of its nature. One farmer known to the writer has for years made a practice of examining his sprouted sets before planting, and rejecting those showing signs of damping off. He knew that, if planted along with the healthy tubers, not only did the affected sets spread disease, but that often they themselves failed to come through.

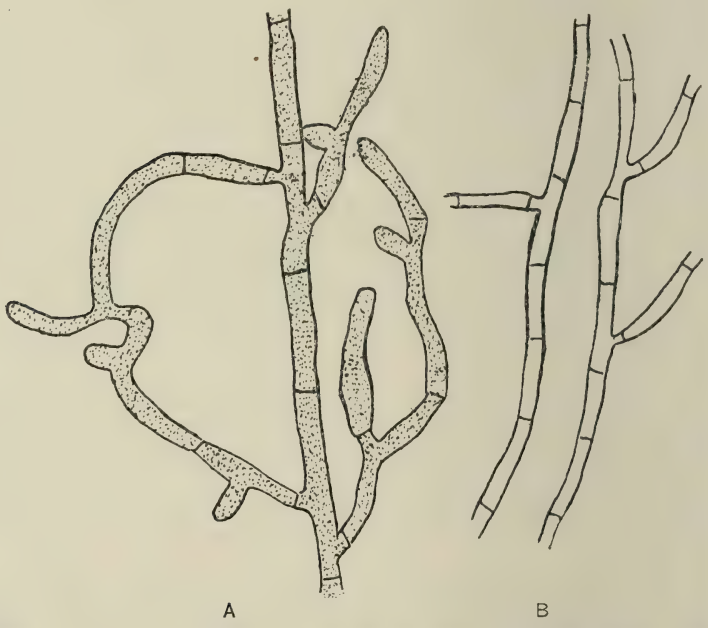

Fig. 1.—(*a*) Young hypha of Rhizoctonia solani; (*b*) Old, brown, and empty hyphæ.

Apart from the investigations of Pethybridge and Güssow, the disease seems to have been overlooked in Great Britain. In Scotland the disease has attracted singularly little attention, and there is no reference to its ravages in current literature. Yet from an examination of potatoes from different parts of Scotland the trouble seems to be very prevalent, and every year to become more pronounced. A large percentage of market potatoes are affected, and particularly those from the "red potato soils" of Scotland.

Characteristics of the Fungus Rhizoctonia.

The fungus has several distinguishing characteristics which mark it off from other similar fungi. There are three distinct phases or stages in its life-history.

(1) *The Rhizoctonia Stage.*—This is the vegetative or growing stage, which attacks the potato stem. In this stage two kinds of hyphæ * may be recognised (Fig. 1)—(*a*) light-coloured hyphæ in the inner tissues of the plant, which may cause a wet rot of the affected part, and ultimately result in the death of the plant; (*b*) dark-coloured hyphæ in the outer tissues, forming a close web or felted covering, which forms a band or girdle round the stem. If the disease has only penetrated the outer layers of the stem, there may be quite a normal development of the shaw, and the plant may even present quite a prolific appearance; and yet, although the fungus is only more or less parasitic upon the outer surface of the stem, it interferes very greatly with the normal physiological movements inside the plant, and prevents the storing up of the starch in the underground stems—*i.e.*, the formation of tubers.

(2) *The Corticium or Spore Stage.*—This stage probably serves for the rapid spread of the disease during the vegetative phase.

Spores of Rhizoctonia were first observed by Rolfs in 1903 on the potato stems, and were considered by Burt to be a new fungus, which he termed *Corticium vagum* (B. & C.), var. *solani* (Burt); in Europe the same fungus is known as *Hypochnus solani* (Prill. & Del.). It is better, in order to avoid confusion, to regard these three fungi as identical.

The spores are very small, and are only formed under favourable climatic conditions such as occur in a cool season with a heavy rainfall. This probably accounts for the great prevalence of the disease during the summer of 1918.

The process of spore formation is as follows:—At the base of the growing potato the hyphæ of the fungus collect and form a fine network round the stem. The outer hyphæ of

* A fungus is composed of a number of long tubular threads or filaments, termed *hyphæ*, which may be branched or unbranched, septate or non-septate.

this layer bear club-shaped basidia,* with four spore-forming branches or sterigmata (Fig. 2). The spores are cast off, and each is rapidly transformed into the vegetative stage.

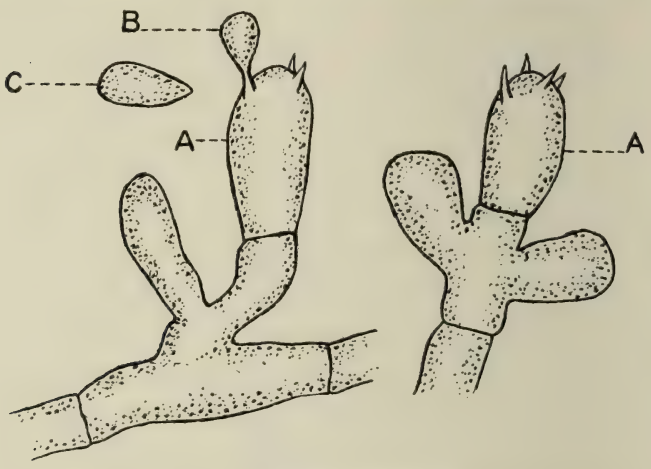

FIG. 2.—Spore formation—
(*a*) Basidium ; (*b*) Spore attached to Sterigma ; (*c*) Spore detached.

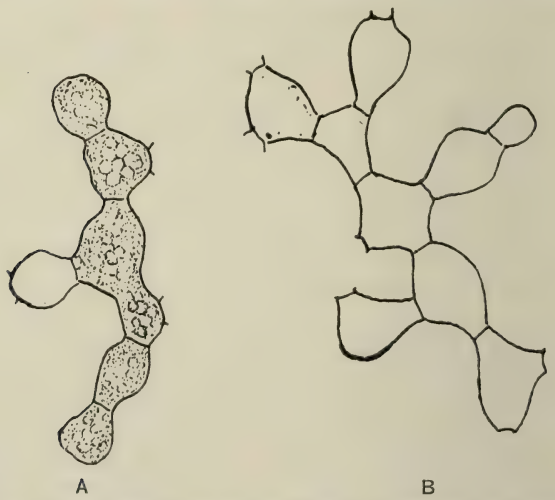

FIG. 3.—(*a*) Young barrel-shaped cells which compose the sclerotia of Rhizoctonia solani ; (*b*) Older empty cells from the sclerotia.

* The swollen terminal portion of a hypha, from which branches arise (generally four in number) which bear spores, is termed a basidium.

(3) *The Sclerotium* or Resting Stage.*—This phase serves to carry the disease over from one growing season to another. The sclerotia are found on the potato tubers at the end of the growing season (Plates I and V). They can likewise be found on the shaws (Plates XX and XXIa). Each is composed of a closely woven mass of hyphæ, which at first is small, white, and soft, but later becomes larger, dark, and hard. The cells of the hyphæ composing the sclerotium are more or less barrel-shaped (Fig. 3), and they act as conidia.† Each under favourable conditions can germinate, and give rise to the vegetative or growing stage of the fungus (Fig. 4).

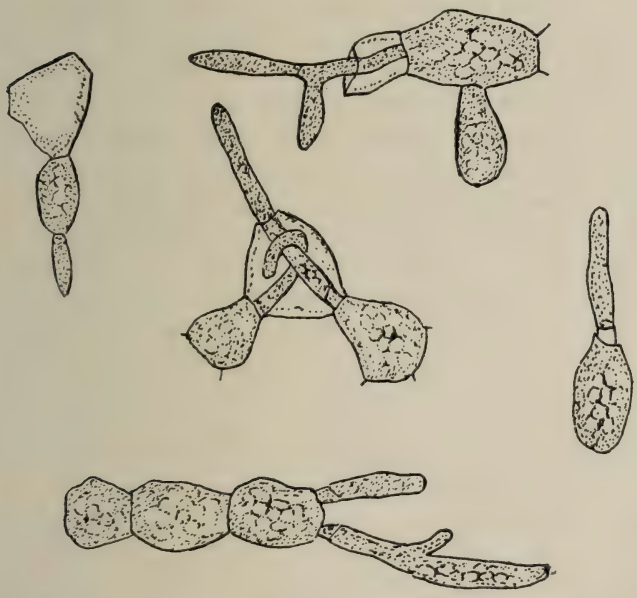

Fig. 4.—Germinating sclerotial cells of Rhizoctonia solani.

* Some fungi under unfavourable conditions become converted into a hard, dry, resistant, blackish mass, the cells of which are more or less round and stored with nutriment. Such a mass is a sclerotium, and represents a resting stage in the life-history of the fungus.

† When part of the hypha of a fungus becomes cut off and forms a spore by an asexual process, the spore is termed a conidium.

It is comparatively easy to grow *Rhizoctonia solani* in pure culture on artificial media such as potato agar or corn meal agar, but *Rhizoctonia violacea* is more difficult to propagate, and has hitherto not been grown on artificial media.

The growth of Rhizoctonia on the potato plant will be considered, for sake of clearness, under three heads :—

(1) *Rhizoctonia solani* on the Tuber.

(2) *Rhizoctonia violacea* or *crocorum* on the Tuber.

(3) *R. solani* and *R. violacea* or *crocorum* on the Stem.

(1) *Rhizoctonia solani*, Kühn, *on the Tuber.*

Diseased potato tubers show on their surface irregularly shaped, slightly raised, dark brown patches (Plate I). These represent sclerotia, and they vary in size from a pin-head up to that of a pea or even larger. They apparently do not cause any serious injury to the tuber, and are only loosely attached to it by a few hyphæ penetrating the surface layer of the tuber. They are frequently regarded as small pieces of earth or soot adhering to the tuber, and can be readily detached by rubbing with the finger nail.

The fungus does not always remain on the surface, but enters the tuber through the lenticels.* In some cases its entrance is indicated by a curious cracking of the skin, which is often very marked, and giving to the surface a reticulate appearance (Plates II and III). In other cases we get a scabby appearance (Plate IV), which is almost identical to that caused by ordinary brown or surface scab. The scab caused by Rhizoctonia is deeper than surface scab, and it frequently heals up and leaves an elevated round scar.

In America the type of scab caused by Rhizoctonia is known as Russet Scab. Probably it is very common in this country, where it is generally confused with Brown or Surface Scab, formerly recognised as caused by *Oospora scabies* (Thaxter), but now by *Actinomyces chromogenes* (Gasperini).

It is rather interesting to note that on lifting diseased tubers affected with Rhizoctonia one frequently finds on their surface small tubers—secondary growths—but whether *R. solani* is one of the common causes of these " second growths " of potato tubers has not yet been determined (Plate VI).

* Breathing pores on surface of tuber.

Diseased potatoes, in which the fungus has penetrated the tuber, often give rise to a peculiar wet rot when they are pitted, resulting in considerable loss.

It seems probable that there are several strains of *R. solani*, each producing its own typical wound or growth on the tuber, so many and varied are the types.

(2) *Rhizoctonia crocorum* (Pers.) DC., *on the Potato Tuber.*

This species is found very often on the Scottish potato; in fact, it is even more common than the preceding.

In rare cases the whole surface of the potato may be more or less completely covered over with a thick felt-like mass of a dark-brown chocolate colour when dry, and violet when wet (Plate V). These masses are similar to the surface sclerotia formed by *R. solani*, but they are more extensive and differ in colour. These sclerotia frequently cause pitting and deep cracks in the tuber (Plate VI). If such an affected tuber be moistened with water, numerous small blackish areas can generally be seen immediately below the surface, which cause the skin of the potato to be elevated at such points (Plate VII). These areas are sclerotia. In shape they may be round, more or less oval, or eye-shaped, and in size five millimetres or even larger. An exaggerated idea is often got of their size from the fact that, if the potato is badly affected, several sclerotia may become confluent and form a large compound sclerotium.

In most of the diseased tubers we have examined the surface sclerotia were scanty and confined to small areas. By far the commoner form was the second type, where the skin had been perforated at the lenticels and the sclerotia showed below the skin.

These sclerotia do not as a rule extend deeply into the tissues, but are mainly confined to the surface layers of the cortex of the tuber. In some cases, however, they make their way right into the "flesh" of the potato and do serious injury, causing discoloration, blackening, and, ultimately, rotting of the tissues. Some of the wounds produced often resemble the burrows made in potatoes by wireworms (Plate VIII). This type of injury has been recently called by an American investigator "Dry core."

(2) *Injuries to the growing Potato Stem by species of Rhizoctonia.*

It is impossible to discriminate between the two species of Rhizoctonia on the stem, but from observation the writer is of opinion that the most serious injuries are caused by *Rhizoctonia violacea* or *crocorum*.

Soon after the potato "seed" is planted the young sprouts are attacked by the fungus which has germinated from the sclerotium (Plates IX and X). The result is that many of the sprouts from an affected set fail to reach the surface, because the tip of a sprout which has been attacked rots (Plate XI). Such a sprout branches below the injured part in an effort to overcome the attack of the fungus. This branch may be again attacked, and the process of branching many times repeated. Thus we find that when a set is badly attacked numerous branches arise from the initial sprouts (Plate XII), the tip of each branch being killed almost as soon as formed, and so the whole substance of the tuber may be used up in the vain attempt of the plant to secure a healthy sprout. This is what happens when the plant is badly attacked.

In other cases there appear above ground from the one plant either a few shaws (Plate XIII) or often an abnormal number, sometimes as many as a dozen (Plate XIV), all either thin and weakly or short and stunted. If these shaws be examined each will be found to be encircled close to the ground surface with a dark band; or again the shaw just below the surface of the ground shows numerous blackish spots or areas. Many such potatoes give up the struggle; the shoots wilt, droop, and die, but others apparently recover. We have seen potato fields where there were numerous blanks, all due to this fungus attacking the germinating tubers, as many as one out of every four sets sometimes failing. The cause of blanks in potato drills can almost invariably be traced to attacks of this fungus.

Stems which survive the first onset of the disease, or are attacked later, show characteristic wounds, often over an inch long, on their surface close to the ground (Plate XV).

The fungus, though not apparently causing any marked damage, so far as external appearances indicate, yet quite evidently seriously interferes with transpiration and the translocation of food.

Some of these stems may be abnormal in length—in exceptional cases over six feet; they are soft and hollow, and lie flat on the ground. They are much branched, and the leaves are almost completely confined to the tip of the branches. When such potatoes are dug only a few small tubers are unearthed; but the reverse very frequently occurs. The stems are small and stunted; the leaves twisted, and with prominent veins. All the foliage is crowded together. Such plants are easily picked out in a field, and the condition is known as "Potato Rosette" (Plates XVI and XVII). Here again the yield of potatoes obtained on digging is small.

In other cases we find that, when the injury to the stem is deep and almost completely severs the plant at the ground surface, two alternatives are open to the plant. (1) It may form aerial tubers (Plates XVIII and XIX). These tubers are formed on the stem between the stem and a leaf base (*i.e.*, in the leaf axils), and are simply attempts of the plant to store up the starch as it is manufactured in the leaves. (2) The second alternative is for the plant to form a large number of small tubers just at the ground surface. This latter condition is termed "Little Potato" (Plate XX).

In many cases, however, the plant, if conditions are favourable, more or less completely recovers, and the only evidence that can be found of it having been attacked is that (1) the leaves show a tendency to curl, especially in dry weather (Plate XXI); (2) sclerotia are found on many of the tubers; (3) the yield is much less than it would be if the potatoes were healthy; and (4) sclerotia can be found at the end of the growing season on the underground stem (Plate XXIa).

It is difficult to estimate, at the present time, the total loss accruing to the farmer in Scotland through planting sets affected with this disease, but it must be very considerable. Loss may occur in the following ways:—(1) From the complete failure of some of the sets to "come through"; (2) from interference with the physiological movements inside the plant

during the whole of its growth, causing a light crop; (3) from the shaws going down very early, and causing early ripening; (4) from wet rot in the pits. Further, the market value of the potatoes may be considerably affected by their scabby appearance. Undoubtedly we are fast approaching the stage when it will be impossible to get seed free from this fungus. (This is the state of affairs in several of the American States.) Some idea, however, of the loss to the farmer can be obtained from the results of an experiment carried out by the Colorado Experiment Station (Plate XXII). The yield of potatoes grown from affected seed is shown in Figs. 1 and 2, and from an equal quantity of unaffected seed (*i.e.*, seed treated with a fungicide) in Fig. 3.

Source of Infection.

We have already indicated the main source of infection. Potatoes bearing sclerotia, if used as seed, will transmit the disease to the sprouting set, and probably this diseased plant will infect those around it. We have noted diseased areas in an otherwise healthy field that can only be accounted for by such an hypothesis. Diseased shaws from a preceding crop, *i.e.*, stems or roots bearing sclerotia, will likewise spread the disease, while a third source of infection may arise from the sclerotia on the stems of weeds growing in the potato drills. The fungus has on occasions been found on all the common weeds. Lastly, the sclerotia seem to be able to exist in the soil, and this must not be overlooked as a potent source of infection.

Treatment.

No treatment, so far as is known, can save the growing plant when once it is attacked. It may partially recover, in fact it generally does, but it will always be a more or less unprofitable plant, owing to the injuries caused to the stem.

It follows that all methods of treating the disease must be preventive, and these can be aptly summarised in the sentence: "Clean seed in clean soil will produce a clean crop."

The first essential, therefore, is to use clean seed. The seed must be free from sclerotia, and it must be remembered that these may be so small as to be almost invisible. Further, it frequently happens that the sclerotia are to be seen only when the seed is wet. It is better to reject all suspicious seed; although some believe in treating suspected and affected seed with fungicides. Obviously if the sclerotia are present in the interior of the tuber, and not on the surface, no treatment will likely prove effective.

Two methods of destroying the fungus (the sclerotia) on the seed potato have been practised in America—(1) treatment with formalin; (2) treatment with a weak solution of corrosive sublimate. Of these the second has given the better results. The strength of solution used is 4 ounces of corrosive sublimate to 30 gallons of water. In order to do this the potatoes are packed in crates, immersed in the solution, taken out and allowed to drain. After the solution has been used for three batches of potatoes it should be renewed.

It is doubtful whether these methods would prove effective in our country. In Scotland, at any rate, the sclerotia on diseased tubers are mainly below the surface, and we are of opinion that such methods of combating the disease would not be of much avail. But no experimental evidence on this point has been hitherto adduced.

A much more practicable measure is to go over carefully all the boxed seed before planting, and reject all sprouted sets showing damping off of the sprouts. This measure would be very effective, were it not for the fact that the majority of the sclerotia only germinate when the set is planted in the soil.

If once the soil has become contaminated we have a much more serious problem to solve. The first measure that suggests itself is to lengthen the interval, as far as practicable, between successive crops, with a view to causing the death of the sclerotia present in the soil and on plant remains. Further, since Rhizoctonia is a parasite upon a large number of weeds, the cleaner the land is kept the less likely is the disease to persist over the interval.

There is much difference of opinion as to the value of applying lime to infected soil. Probably quicklime will kill a certain number of the sclerotia, and should always be applied when the soil is badly polluted. The application of lime will, in addition, improve the tone of the soil, and that will serve to keep the fungus in check. It is found that the disease is most prevalent under poor soil conditions, especially when soils are sour. Of course, the application of lime may cause an increase of ordinary scab, but it will be necessary to choose between two evils, and surface scab is not nearly so serious a disease as the various Rhizoctonia diseases.

In particular we might draw special attention to the following points :—

(1) From close observation extending over two years the disease is prevalent in Scotland, and, unless radical measures are taken to control it, great losses will be incurred by the farmers.

(2) There is a great and urgent necessity for a more detailed study of this and of all other potato diseases common in Scotland. We have diseases peculiar to Scotland, and yet we have even now to turn to other countries for information, which may or may not be of value in solving our difficulties.

A bibliography on this subject is appended, but much of the information contained in the various publications is mainly of historical value.

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PLATE I.—Sclerotia of Rhizoctonia solani on tuber.

PLATE II.—Reticulate appearance of tuber badly affected with Rhizoctonia.

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PLATE III.—Reticulate appearance of tuber badly affected with Rhizoctonia. The tuber is apparently endeavouring to shed its outer coat.

PLATE IV.—Form of scab caused by Rhizoctonia.

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PLATE V.—Sclerotia of Rhizoctonia crocorum on tuber.

PLATE VI.—Cracks and wounds on tubers caused by Rhizoctonia entering the tuber. In the smaller tuber note "second growth" protruding from the back.

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PLATE VII.—Sclerotia of Rhizoctonia crocorum on tuber.

PLATE VIII.—Pitting on tuber caused by Rhizoctonia.

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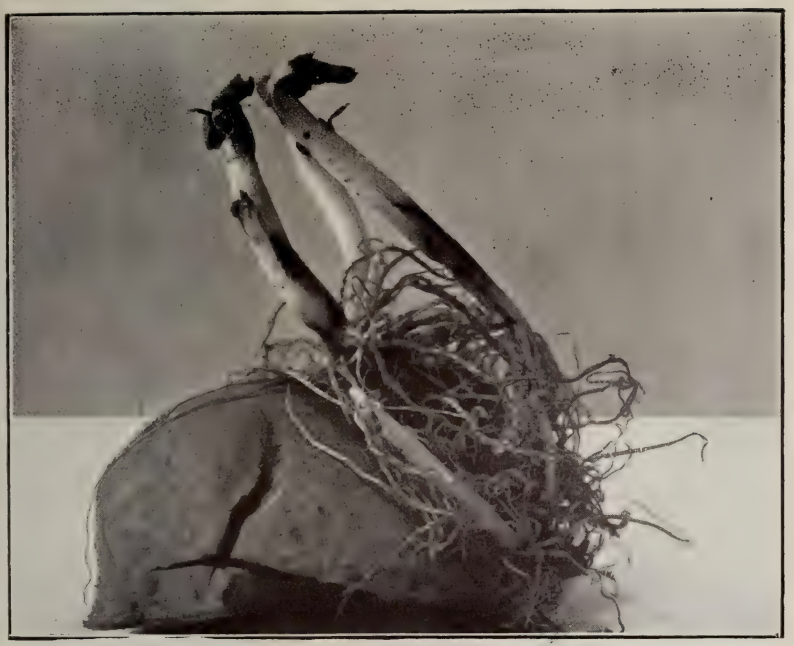

PLATE IX.—The young sprouts of a potato set attacked by the vegetative form of the fungus.

PLATE X.—Reticulate form of scab on potato set, caused by Rhizoctonia in the resting stage having penetrated the tuber. The young sprouts have been attacked by vegetative form of fungus, which has germinated from the resting stage on tuber.

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PLATE XI. — Young sprouts attacked by fungus, those on right completely severed.

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PLATE XII.—Potato set attacked by Rhizoctonia, showing large number of thin weakly diseased sprouts already forming "little potatoes."

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PLATE XIII.—A potato plant grown from tuber affected with Rhizoctonia solani, see sclerotia on surface of set. The shaws are thin and spindly and sparse of foliage, and have small wounds on underground surfaces, produced by vegetative form of fungus, which has arisen from resting stage on tuber.

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PLATE XIV.—A potato plant grown from tuber affected with Rhizoctonia violacea, as shown by sclerotia and scab. The shaws, abnormal in number, are short and stunted, and show on their surfaces large wounds produced by vegetative form of the fungus, which has developed from resting stage on tuber.

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PLATE XV.—Wounds on potato shaws caused by shaw being attacked by vegetative form of Rhizoctonia. The shaw has recovered, but wounds persist.

PLATE XVI.—Stems of potato plant affected with Rhizoctonia—a bad case of "Rosette."

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PLATE XVII.—"Potato Rosette."

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PLATE XVIII.—Potato-plant attacked by Rhizoctonia, showing formation of aerial tubers.

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PLATE XIX.—Aerial tubers on a dead shaw.

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PLATE XX.—"Little Potato." Note sclerotia on tubers. The original wounds on root are now filled up with sclerotia and appear black.

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PLATE XXI.—"Leaf Curl"—a common symptom in plants more or less recovered from an attack of Rhizoctonia.

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PLATE XXIA.—Root of potato plant shown on Plate XXI. Root almost normal, except for small hole near base originally caused by an attack of Rhizoctonia. Hole is now filled with the sclerotia of the fungus.

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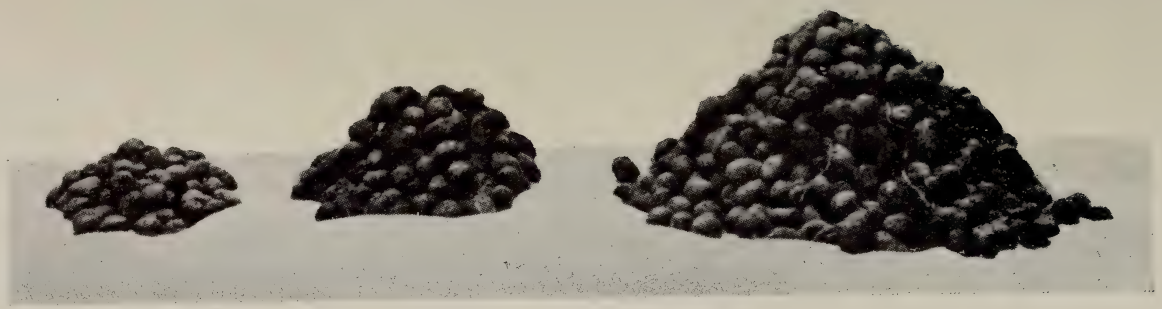

Fig. 1. Fig. 2. Fig. 3.

PLATE XXII.—The yield of potatoes from two lots of affected seed is shown in Figures 1 and 2; that from a quantity of seed equal to that used in either 1 or 2 in Figure 3.

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ULLETIN No. 95.

The West of Scotland Agricultural College.

REPORT

ON

SUGAR-BEET TRIALS, 1918.

BY

R. A. BERRY, F.I.C.,

Professor of Agricultural Chemistry.

GLASGOW:

PRINTED BY ROBERT ANDERSON, 142 WEST NILE STREET.

1919.

REPORT ON SUGAR-BEET TRIALS, 1918.

BY

Professor R. A. BERRY.

EXPERIMENTS on the growing of sugar-beet, which were commenced in 1917*, were continued in 1918 at the following centres :—

Experiment Station, Holmes Farm, Kilmarnock.
Chas. M. Douglas, Auchlochan, Lesmahagow.
John Douglas, High Balyett, Stranraer.
George Will, Crichton Institute, Dumfries.
Hugh W. B. Crawford, Chapmanton, Kirkcudbright.
Andrew M. Baird, Cumnock, Ayrshire.

One-half acre plots were grown. The seed was imported.

Particulars of the manuring, cultivation, &c., for the 1918 crop are shown in Table I, page 76.

* Bulletin No. 83, West of Scotland Agricultural College, for the results of the 1917 experiment.

TABLE I.

Centre.	Type of Soil and Previous Crop.	Height above Sea Level. Feet.	Manures per Acre.	Crop. Date of Sowing.	Crop. Date of Singling.	Crop. Date of Lifting.	Roots Bolted. Per Cent
Auchlochan, ...	Free Loam. Potatoes.	730	Dung, 15 tons. Superphosphate, 3 cwts. Bone Flour, 1 cwt. Sulphate of Ammonia, 1 cwt. Sulphate of Potash, 28 lbs.	May 9	June	Oct. 30	15
High Balyett, ...	Light Loam. Oats.	150	Superphosphate, 3 cwts. Bone Flour, 1 cwt. Sulphate of Ammonia, 1 cwt. Sulphate of Potash, 28 lbs. Salt, 2 cwts.	May 28	July 16	Nov. 16	16
Crichton, ...	Light Loam. Oats.	150	Dung, 15 tons, Superphosphate, 1·5 cwts. Bone Flour, 56 lbs. Sulphate of Ammonia, 56 lbs. Sulphate of Potash, 14 lbs.	May 18	June 19	Nov. 12	1·5
Cumnock, ...	Light Loam. Turnips.	760	Dung, 15 tons. Superphosphate, 5 cwts. Sulphate of Ammonia, 1 cwt. Potash Salt, 5 cwts.	May 20	June 22	Nov. 1	1·0
Chapmanton, ...	Light Loam. Oats.	300	Dung, 15 tons. Superphosphate, 1·5 cwts. Bone Flour, 56 lbs. Sulphate of Ammonia, 56 lbs. Sulphate of Potash, 14 lbs. Salt, 1 cwt.	May 21	June 21	Nov. 8	3
Holmes Farm, ...	Free Loam. Oats.	80	Dung, 12 tons. Superphosphate, 3 cwts. Steamed Bone Flour, 1 cwt. Sulphate of Ammonia, 1 cwt. Sulphate of Potash, 56 lbs.	May	June	Dec. 6	5

As the list shows, Centres were selected in each of the following Counties:—Ayrshire, Wigtownshire, Dumfriesshire, Kirkcudbrightshire, and Lanarkshire, so that the soil and climatic conditions under which the crop was growing were representative of considerable areas in the West of Scotland. The height above sea level varied between 150 to 760 feet at the respective Centres.

The analytical results, along with the yields per acre for the two years, are summarised in Table II, page 78. The chemical analyses were made in the Chemistry Department of the College. The weight per acre of roots was ascertained by each of the experimenters.

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TABLE II.—1918.

CENTRE.	Date of Sampling.	ROOTS.			JUICE.			YIELD PER ACRE.	
		Average Weight of Washed Root Sampled. Grams.	Dry Matter Per Cent.	Sugar Per Cent.	Specific Gravity.	Sugar Per Cent.	Purity of Sugar Per Cent.	Roots Washed. Tons.	Sugar. Tons.
Auchlochan, ...	Oct. 30	446	22·57	14·82	1·077	15·60	82·0	11·25	1·67
High Balyett, Stranraer, ...	Nov. 16	513	23·12	15·58	1·083	16·40	86·0	10·5	1·64
Crichton Institute, ...	Nov. 12	597	23·52	16·49	1·084	17·36	88·0	16·1	2·66
Holmes Farm, ...	Dec. 6	766	22·15	15·26	1·080	16·06	85·0	17·2	2·63
Cumnock, ...	Nov. 1	776	20·07	13·18	1·073	13·87	83·0	15·0	1·98
Chapmanton, ...	Nov. 11	457	22·51	15 60	1·081	16·42	87·0	14·0	2·18
Average, 1918, ...	...	592	22·32	15·15	1·079	15·95	85·0	14·01	2·13
Average of Six Centres, 1917,	...	755	22·86	15·71	1·083	16·55	87·3	9·3	1·46
Average for the Two Years, ...	..	**673**	**22·59**	**15·43**	**1·081**	**16·25**	**86·1**	**11·65**	**1·79**

Apart from the influence of soil and climate, the factors of importance in connection with the growing of sugar-beet are, the yield per acre of roots, the percentage of sugar in the root, and the purity of the sugar in the juice. On these points the average results obtained for the two years in the West of Scotland compare very favourably with the figures found in typical sugar-beet growing countries.

In these countries, the crop is usually lifted in the month of September, while in the West of Scotland the crop is not, as a rule, ready for lifting until the months of October or November. During the extra weeks of growth the storage of sugar by the plant continues. A good example of the effect of a prolonged growing period upon the sugar-content is supplied in the case of sugar-beet grown in 1918 on the island of Arran, and which was not lifted until February 3rd, 1919. The percentage of sugar in the root was found to be 18·6 per cent.

The two seasons, 1917 and 1918, were normal, and there was in both years an absence of early frosts in the autumn. Beetroots, like mangels, are injured by frost; but, with suitable methods of cultivation, the beetroots should be completely covered with soil, which acts as a protection against injury from short spells of frosty weather. Deep cultivation and liberal manuring are necessary for the successful growing of this crop.

The proportion of "bolted," or roots gone to seed, in 1918 varied between 1 and 16 per cent., respectively, of the total crop at the different Centres; in 1917 the figures varied between 3 and 30 per cent. No allowance for "bolted" roots was made in the yields given in the above Table II. In all probability, the tendency of the plants to "bolt" can be sensibly diminished by employing seed which has been grown in Scotland. The proportion of soil adhering to the roots after lifting amounted on an average to about 20 per cent. of the gross weight of roots.

Bulletin No. 96.

The West of Scotland Agricultural College.

SOME BEE DISEASES

—BY—

JOSEPH TINSLEY, B.B.K.A.(1st Class), S.B.A. (Expert).
(Lecturer on Beekeeping).

Glasgow:
Printed by Robert Anderson, 142 West Nile Street.
1920.

SOME BEE DISEASES.

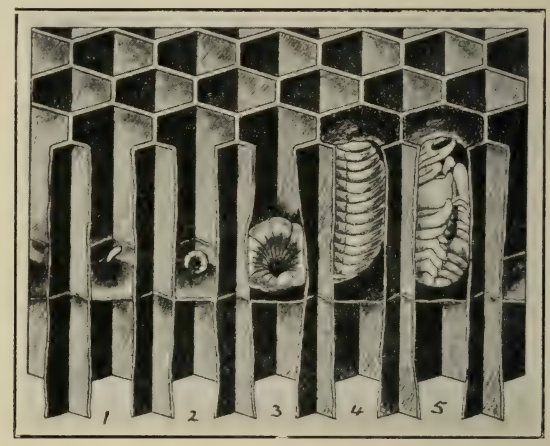
Joseph Tinsley, B.B.K.A.(1st Class), S.B.A. (Expert),
Lecturer on Beekeeping (West of Scotland College of Agriculture).

Of all the diseases with which the beekeeper has to contend, probably the most common is that known as Foul Brood. The disease has been so named because of the foul smell which emanates from the dead brood. But as death of the brood, even when accompanied by putrefactive changes, may be due to different causes, the name is a general one. In this country the term Foul Brood is commonly applied to three different diseases, viz., European Foul Brood, caused by *Bacillus alvei*; American Foul Brood, caused by *Bacillus larvæ*; and Sac Brood. In the case of Sac Brood the causative agent has not yet been determined.

Foul Brood (Bacillus alvei).—Before we proceed to examine this disease in detail it may be well to recall the social conditions under which bees live. The rapid manner in which the infection is transmitted will then be the more readily appreciated. In the first place, a colony of bees varies in number from 20,000 to 40,000 individuals, and yet takes up relatively little space. Again, all the cells in the hive—those in which the young hatch out and those in which the honey is stored—are made from wax elaborated by the bees themselves. Thirdly, food is prepared in the bodies of the nurse bees for the sustenance of the larvæ, while during exceptional periods food is conveyed from the workers to the queen direct. Finally, the cleanliness of the hive is effected by the workers themselves carrying out of the home any objectionable material. It will thus be seen how easily a disease of an infectious nature spreads in a colony of bees, and how important it is that the beekeeper should be able to diagnose all diseases in their initial stages in order to prevent rapid spreading and obviate financial loss.

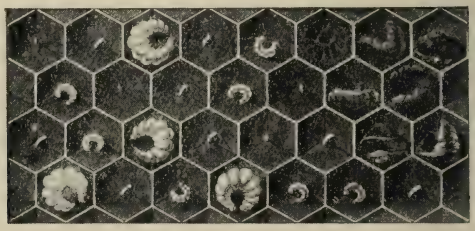
Symptoms.—If we examine a normal brood comb we will find eggs, larvæ, and brood in all stages of development. Close inspection will show that eggs newly deposited by the queen stand upright in the cell. On the second day these same eggs rest at an angle of 45 degrees. On the third day each develops into a small grub curled up like the letter "C." These grubs are pearly white in colour, and

present a glistening appearance as they lie flat on the bottom of the cell. As a result of the special feeding given them by the



Development of the Bee.

attendant workers they grow rapidly, so that by the seventh day they present a white and plump appearance. Development takes place rapidly, and on the ninth day the cell containing the developed larvæ is covered over with a porous capping. On the twenty-first day the worker bee bites its way through the capping and takes its place in the hive. These are the conditions in a healthy colony, but in a colony in which Foul Brood occurs the first noticeable difference is in the condition of the larvæ. Instead of all the grubs being white and plump and curled up like the letter "C," as they would normally appear, they will be observed to take up very irregular positions. Some will be almost perpendicular, while others will be horizontal. Instead of appearing pearly white, the grubs will be coloured a faint

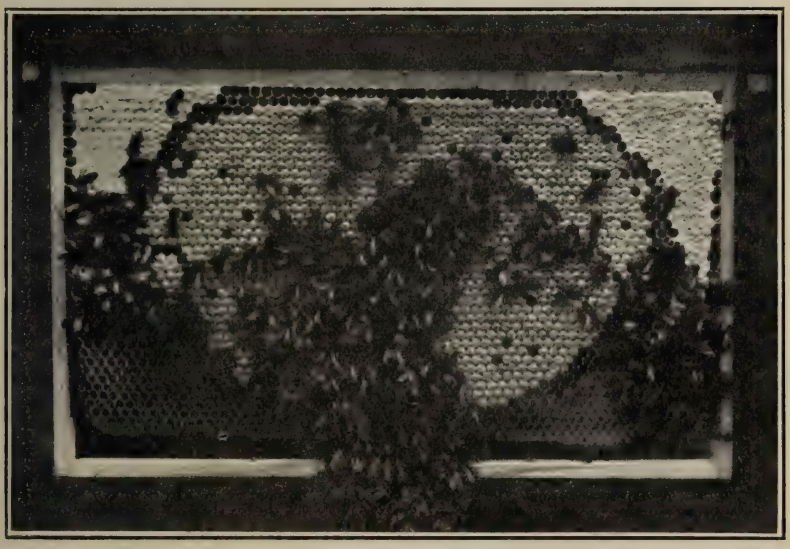


Early Stages of Foul Brood in Seven Cells.

buff or yellow. At this initial stage of the disease a cure can usually be effected if the colony is fairly strong, but immediate attention is necessary if the treatment is to be successful.

Treatment of Foul Brood in initial stage.—The queen should be destroyed and a new queen of a healthy variety, such as Dutch or Italian, substituted. The colony should be given a complete change of hive. This is imperative. All the old combs should be taken away and burnt, and should be replaced by frames fitted with sheets of worker foundation. The introduction of a fresh queen, the change of hive, and the addition of new combs will materially assist in checking the disease. The colony will be reinvigorated, and the stamina of the future inhabitants of the hive will be greatly improved.

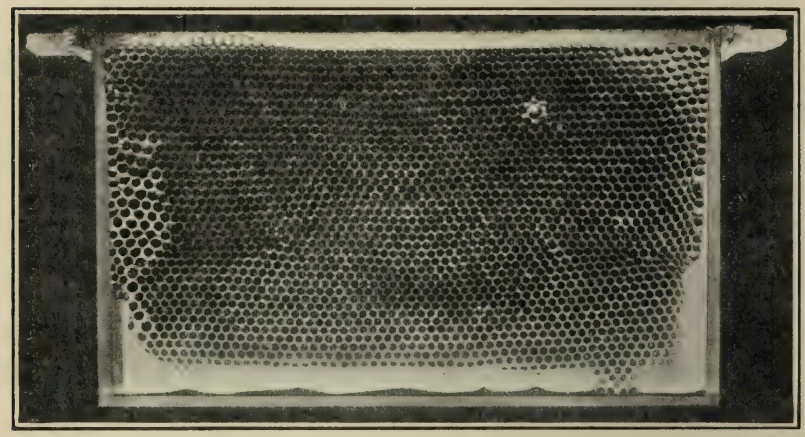
In consequence of the infectious nature of the disease, all operations should be carried out in the evening, when the bees have finished flying for the day. The beekeeper may himself be a means of spreading the infection by carrying the spores of the disease on his hands and clothes. Disinfection of everything that comes into contact with the hive or hive contents should be carefully carried out.



Comb of Brood in a Healthy Condition.

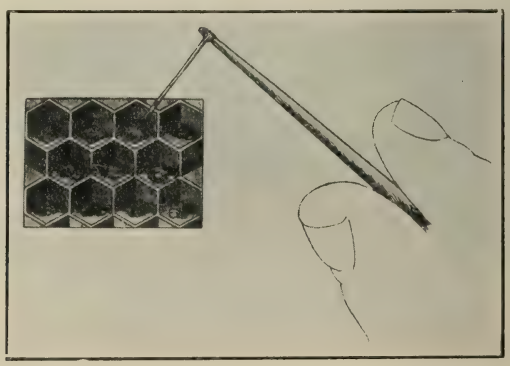
Second stage of the disease.—If the beekeeper has failed to observe the malady in the initial stage he will soon be confronted

with a much more virulent condition of the disease. By this period the bees will have sealed over many of the grubs that were attacked by the disease in its early stages. The cappings of the brood cells,



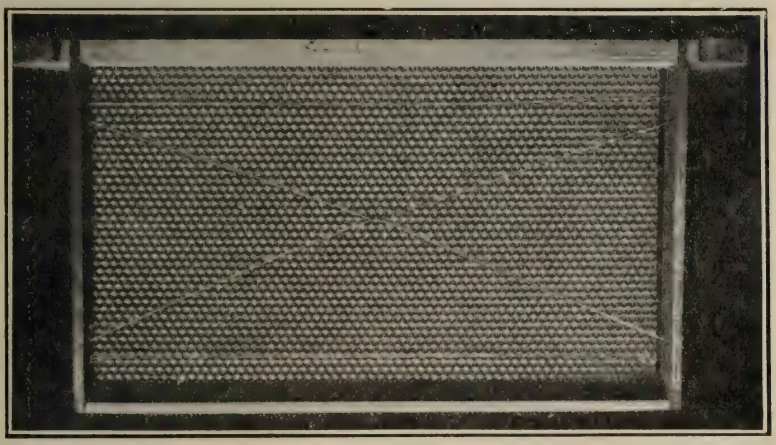
Empty Brood Comb requiring renewing.

instead of being light brown in colour and convex in appearance, will be dark brown and flat or indented; occasional cells may have minute perforations in the covers. If a match is pressed into one of these cells and then withdrawn, a brown, ropy, tenacious mass will adhere to the wood, and an unpleasant odour reminiscent of the glue-pot will be observed. The colony will diminish rapidly in numbers as a result of the high death-rate in the cells.



Foul Brood. Ropy Stage (B. alvei).

Treatment of Foul Brood in the second stage.—If the colony is in a weak condition the bees should be destroyed at once. This will save the beekeeper from further financial loss by preventing other colonies becoming infected. But if the colony is fairly strong, remedial measures should be applied forthwith. The queen should be killed. In order that the whole of the healthy brood still in the hive may be brought to maturity it is advisable to keep the colony without a queen for at least eleven days. Immediately the colony realises its queenlessness it will endeavour to raise a queen from the larvæ in the hive. To prevent this, make an examination of the colony about the seventh day after the destruction of the queen, and remove all queen cells in the course of construction. On the eleventh day, when practically all the healthy brood will have hatched, the bees should be brushed or shaken off their combs and placed in a clean hive. This hive must be fitted with frames into which foundation has been inserted and wired. A new queen is then given, Dutch or

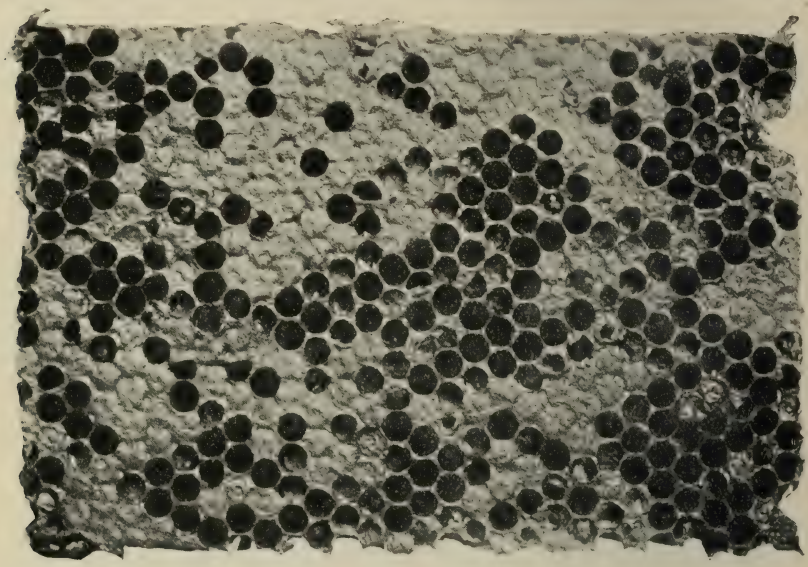


Wired Frame, with Foundation.

Italian preferred. A little feeding with sugar syrup will help the colony to build up quickly. The brood combs of the diseased hive as well as the wraps must be burnt, and the interior of the hive thoroughly scraped. All dirt, wax, and propolis removed by this operation should be carefully collected and destroyed by fire. The hive, internally and externally, should be washed and disinfected. A painter's blow-lamp may be used to fire all infected parts.

Beekeepers who are not disposed to apply this thorough treatment

may adopt the following method :—Shake all the bees off the combs, including the queen, into an old skep or box, and allow this artificial swarm to remain without food for forty-eight hours. At the end of



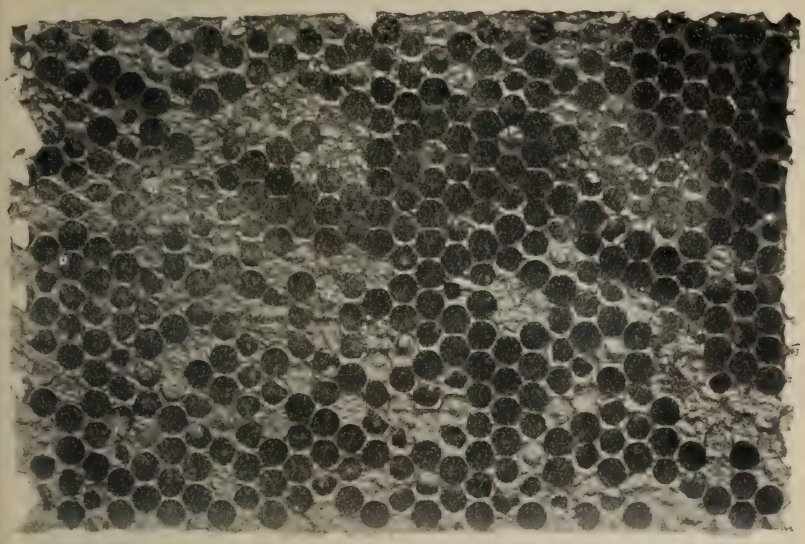
Foul Brood. Second Stage (B. alvei).

this time transfer the swarm to a clean hive, which has previously been fitted with frames into which foundation has been placed. Re-queen either now or in a few days' time. Destroy the receptacle in which the fasting took place.

In both cases it is advisable to destroy the brood combs and quilts. The latter can be easily replaced. The hive, if a good one, should, as in the preceding method of treatment, be carefully scraped to remove all wax and propolis, then washed with soapy water, and afterwards scorched with a painter's blow-lamp in order to destroy any lurking disease spores. If a blow-lamp is not available, the interior of the hive should be painted with methylated spirit and fired, the flames being subdued by means of a wet bag. As before, the material scraped off the hive should be carefully collected and burnt.

Treatment of Foul Brood in advanced stage.—The last stage of the disease is distinguished by the sunken appearance of the cell caps. The internal decaying mass dries into the form of a brown scale, which will be seen at the base or the side of the cell. The colony will have dwindled in numbers, and, as there is no possible cure at

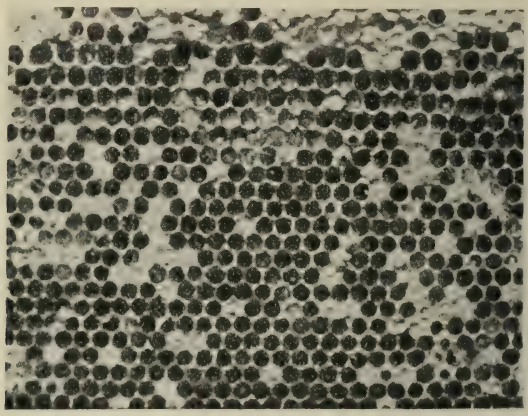
this final stage, it is advisable to destroy by fire the contents of the hive, leaving only the shell for future use. If the hive is an old one it should be burnt as well.



Foul Brood. Third Stage (B. alvei).

American Foul Brood (**Bacillus larvæ**).—This disease is not quite so widespread as the other form of Foul Brood. When the larvæ are first attacked they turn a light chocolate colour, and as the disease advances they become darker, resembling roasted coffee in appearance. This disease appears to attack the larvæ at a later stage than the other form of Foul Brood, usually about the time the brood cells are capped over. As the disease progresses the larvæ shrink in size, with the result that the cappings become sunken and perforated. A glance over the brood combs will reveal the presence of great numbers of these cells with indented cappings. Within will be seen the shrivelled portion of the larvæ which have died from the disease. The colour of this diseased mass will be dark brown. If a match is inserted and slowly removed the decomposed material will attach itself to the wood and stretch in a long line before breaking. The decaying matter has a pronounced and rather offensive odour. This disease does not bring about the extinction of the colony as quickly as the other form of Foul Brood, but nevertheless it is fatal in the long run.

Once a colony is attacked, its end is certain unless the necessary remedies are applied.



American Foul Brood.

Treatment of American Foul Brood.—As before, all work should be performed at evening, when the bees have finished flying for the day.

Brush or shake all bees and queen off the combs into a skep or receptacle. Allow them to remain in a fasting condition for forty-eight hours. Then transfer to a clean hive, with frames fitted with starters only. Re-queen with Italian or Dutch strains. Destroy all brood combs and quilts. If the hive is worth keeping, scrape the interior of all wax and propolis, collecting such matter, which must afterwards be burnt. Wash the inside and outside with soapy water, to which a disinfectant should be added, such as Calvert's No. 5 carbolic acid. Scorch the interior of the hive to destroy all sources of infection.

Sac Brood.—Sac Brood is sometimes called Pickled Brood. The larvæ die in the cells, but the remains, instead of decomposing, as in the case of Foul Brood, into a fluid condition, become attached to the side of the cell in the form of a sac. This form of the disease is often confused with the other two forms of Foul Brood, but in this respect the beekeeper need not have any doubt, as the cell-content is odourless. Cappings will also be noticed with minute holes, showing that the work of covering the brood cells was imperfect. Starved or ill-nourished brood would be a better name. A young and prolific queen, together with a new comb or two, will usually effect a cure.

Bulletin No. 97.

The West of Scotland Agricultural College.

REPORT ON CATTLE-FEEDING EXPERIMENTS.

(a) Beef Production with or without concentrates.
(b) Fish-Meal for Fattening Cattle.

By

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REPORT ON CATTLE-FEEDING EXPERIMENTS.

THE four experiments dealt with in this report were carried out at the Crichton Farm, Dumfries, and the West of Scotland Agricultural College Farm, Kilmarnock, both farms being well equipped with loose boxes suitable for such work.

The main objects in view in the first two experiments were—

(1) To ascertain the relative rates of progress made by cattle receiving no concentrates as against those receiving a moderate amount; and

(2) To measure the benefit from feeding good clover and ryegrass hay as part of the ration, and ascertain to what extent it could replace concentrates.

The first experiment was conducted in the winter of 1917-18, and at a time when feeding-stuffs were exceedingly scarce. There was not sufficient to provide a full ration for the different classes of stock, and in the distribution of what was available dairy cows in milk were receiving first consideration. Under such circumstances, it seemed highly desirable that experiments should be conducted to ascertain to what extent concentrates could be dispensed with in feeding for the production of beef.

For the experiment under consideration, eighteen polled cattle were selected out of a group of twenty that were available. Of the eighteen, twelve were Aberdeen-Angus crosses, and six Red Poll crosses. Altogether, they were a particularly good lot, and their average age at the commencement of the experiment was about twenty-one months.

The eighteen animals were divided into three groups, with four Aberdeen-Angus crosses and two Red Poll crosses in each. The groups were also made as uniform as possible in all other respects, and the average live-weight of the animals in each at the beginning of the experiment was as follows:—

	cwt.	qr.	lb.
Group I.	6	2	10
„ II.	6	2	11
„ III.	6	2	13

It was decided that the rations to be tested should consist of (1) straw and swedes; (2) straw, swedes, and hay; and (3) straw, swedes, hay, and concentrates. The actual quantities fed per head per day to the animals in the different groups were as follows:—

Group I. 72 lb. swedes, straw and water *ad lib.*
„ II. 6 lb. hay, 72 lb. swedes, straw and water *ad lib.*
„ III. 3 lb. concentrates (increased later to 4 lb.)
6 lb. hay, 72 lb. swedes, straw and water *ad lib.*

The concentrates consisted of a mixture, in equal parts, of crushed oats and decorticated cotton-cake, these foods being chosen because there was a little decorticated cotton-cake available, and also in view of the very satisfactory results previously obtained from a similar mixture in experiments conducted at the same centre. (See Bulletin No. 67, West of Scotland Agricultural College.)

As already indicated, the allowance of concentrates was increased from 3 to 4 lb., and this increase took place at the end of the sixth week. It was intended to increase the allowance of swedes also, but it was found that the animals in the different groups did not clean up an increased amount, consequently the allowance of swedes was not increased, but kept at 72 lb. per animal per day.

The foods, with the exception of the fodder, were always carefully weighed and measured. The fodder was weighed at the commencement of the experiment, then estimated thereafter, with an occasional weighing as a check from time to time.

In view of the material differences in the rations fed, the feeding time-table had to be varied somewhat. It was as follows:—

The animals in Group I. received their roots in three equal portions, morning, noon, and evening—and these were followed with a foddering of straw, rather more being given in the evening than in the morning or at midday.

Those in Group II. were treated similarly to those in Group I., with the exception that in the evening the foddering of straw was replaced with hay.

Those in Group III. received one-half of the daily allowance of concentrates in the morning before being fed their roots, and the other half in the evening also just before receiving their roots. Apart from the concentrates, the animals in this group were treated exactly the same as those in Group II.

The experiment was continued for a period of thirteen weeks,

and the cattle weighed at intervals during that time. All of the animals made exceptionally good progress, but the differences due to the feeding were, after the first few weeks, very marked, and readily apparent even without the help of the weigh-bridge.

The animals in Group I. made an average weekly gain of almost 11 lb. per head, but at the end of the experiment they were still far from fat, though they had grown considerably. They had not the same sappy appearance as the animals in Group III., but were harder and drier in skin and hair.

The progress made by the animals in Group II. was decidedly ahead of that of those in Group I., being over 14 lb. per head per week; but at the end of the thirteen weeks these also, though they had grown well and put on a good deal of flesh, could not be considered ready for beef purposes.

Group III. was outstanding, and all the animals in it made remarkable progress, the average weekly gain per head being very nearly 20 lb. The addition of the decorticated cotton-cake and crushed oats had made a very great difference in their general appearance, condition, and weight. The animals were in a sappy, well-thriven condition, and quite fit for "first grade" beef on the conclusion of the experiment.

The average live-weights of the animals in each group at the beginning and end of the experiment, as well as the total and average weekly gains, are given below:—

TABLE I.

Group.	Ration.	Average live-weight at beginning of experiment.			Average live-weight at end of experiment.			Increase in live-weight.			Average weekly increase.
		cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.	lb.
I.	Straw and swedes .	6	2	10	7	3	12	1	1	2	10·9
II.	Straw, swedes, and hay . . .	6	2	11	8	1	2	1	2	19	14·4
III.	Straw, swedes, hay, and concentrates .	6	2	13	8	3	19	2	1	6	19·8

The average weekly increases recorded above are exceptionally good, and certainly above the average of what generally results from feeding rations of the kind employed; but as previously pointed out, the cattle selected for the experiment were young growing animals of a particularly good type, and in view thereof the response to the different rations was all the more marked.

It is scarcely possible to bring out the financial aspect of the experiment because of the marked difference in the condition of the animals comprising the different groups at the end of the feeding period. For example, those in Group I. were not only fully 1 cwt. lighter per animal than those in Group III., but they were also a long way from being fat; and consequently, if sold in that condition, they would not have realised anything like the same price per cwt. Moreover, the real aim of the experiment was not to get at the relative costs of beef production from the three methods of feeding, but to *show the relative rates of progress on the different rations*, and ascertain if beef production was possible without concentrated feeding-stuffs when dealing with cattle of the type employed.

The results obtained demonstrate the value of good ryegrass and clover hay as part of the ration for fattening cattle, as the animals getting the hay made quite good progress, even without concentrates. They were, of course, a long way behind those in Group III., but with a few weeks' additional feeding they would have been sufficiently well fleshed to furnish quite good beef. As it was, they were, at the end of the thirteen weeks, very well forward in condition, and the results obtained from feeding ryegrass and clover hay really confirmed the opinion that many feeders held as to its value for fattening cattle.

The results also show that, when dealing with young cattle of the type already described, a ration consisting of swedes and straw cannot be recommended for the production of beef, even when there is, as was the case at the time the experiment was conducted, a grievous shortage of feeding-stuffs. Further, when we consider the amount of food consumed by the respective groups of cattle, for every 100 lb. live-weight increase produced, irrespective of the rate of fattening, there is very little to be found in favour of that method of feeding. Particulars regarding the varying amounts of food required are given below:—

TABLE II. FOODS CONSUMED PER 100 LB. LIVE-WEIGHT INCREASE.

Group.	Swedes.	Straw.	Hay.	Concentrates.
	lb.	lb.	lb.	lb.
I.	4614	1538	...	...
II.	3504	778	292	...
III.	2539	281	211	124

The figures given for straw, in view of the fact that it was fed *ad lib.*, are not quite so accurate as those for the swedes,

hay, and concentrates, but they are substantially correct. The approximate average daily consumption of straw by the animals in Group I. was 24 lb. per head; in Group II., where hay formed part of the fodder, 16 lb. per head; and in Group III., where both hay and concentrates were fed, 8 lb. per head.

In the above table, if the figures for Groups II. and III. are considered, it will be readily apparent, even as regards the live-weight increase made by the animals in these groups, irrespective of rate of fattening, that 124 lb. of concentrates, consisting of decorticated cotton-cake and crushed oats in equal amounts, actually took the place of 965 lb. of swedes, 497 lb. of straw, and 81 lb. of hay.

In the same way it will be found, by considering Groups I. and II., that 292 lb. of ryegrass and clover hay replaced 1110 lb. of swedes and 760 lb. of straw.

These results demonstrate the value of hay and the importance of feeding concentrates, along with straw and roots, in order that these farm products may be utilised to the fullest advantage. They also show that a relatively small quantity of concentrates may effect great economy in the use of straw and roots, and thus enable a much larger head of stock to be maintained.

Second Experiment.

A further experiment was carried out at the same centre in the following winter (1918-19), mainly for the purpose of confirming the results obtained in the experiment already referred to, but also with a view to ascertaining if fish-meal was likely to prove a suitable foodstuff for fattening cattle.

The very great reduction in imports of concentrated feeding-stuffs arising out of war conditions had been the means of bringing this feeding-stuff more into the limelight; moreover, it had previously been employed with excellent results in feeding trials at the College Farm with such classes of stock as pigs, calves, and dairy cows, but its suitability as a food for fattening cattle had not been tested at that centre.

Under normal conditions, and amidst a plentiful supply of well-known feeding-stuffs, the value of fish-meal had not been fully appreciated in this country. It was used by only a relatively small number of stock feeders: there was comparatively little home demand for it, and altogether it was not looked on as a feeding-stuff of much consequence. At the same time this home product which we despised and rejected, or at least neglected, was highly valued on the Continent for the feeding of all classes of stock, and of the quantity produced in this country per annum (approximately 40,000 tons in 1913), fully

three-fourths were exported, the greater part of which went to Germany.

Stock-feeders on the Continent are not fools; they had practically the same choice of feeding-stuffs as we ourselves had, but yet they purchased fish-meal from us for the feeding of their stock. The natural conclusion is that *they did so because they had found that the results obtained from the use of that feeding-stuff compared favourably with those obtained from the use of other concentrated foodstuffs.*

In the circumstances it seemed highly desirable that further trials should be carried out here, so that we might satisfy ourselves as to the part that fish-meal might play in stock feeding.

For the experiment under consideration seventeen cattle were available. They were mostly Aberdeen-Angus crosses with, in addition, a few Red Poll crosses. and also some Shorthorn crosses. Altogether, these were cattle of quite a good type, but there was a little variation in age and in weight, and they were not just so uniform as the previous year's lot. From the total number available fifteen were selected for the experiment, and they were utilised as follows: Three groups of cattle, with three animals in each, were arranged with a view to obtaining confirmation of the previous year's results, and these groups were made as uniform as possible in every way.

For the purpose of ascertaining the suitability of fish-meal for fattening cattle a fourth group was provided, and as fish-meal had not been used in the experiment conducted in the previous year, six animals were put in this group, so that a more reliable result might be obtained than would have been possible with only three animals.

The cattle in Groups I., II., and III. were fed in exactly the same way as the animals in the corresponding groups in the previous year's experiment, and this applied both to the kinds of food and the amounts fed.

The ration fed to the animals in Group IV. was identical to that for those in Group III. as regards swedes, hay, and straw, but decorticated cotton-cake was replaced by fish-meal, and the quantities of fish-meal and crushed oats were adjusted in such a way that the two rations supplied the same amounts of protein. Instead, $1\frac{1}{2}$ lb. of decorticated cotton-cake and $1\frac{1}{2}$ lb. of crushed oats, 1 lb. of fish-meal and 2 lb. of crushed oats were fed, and these amounts were increased at the end of the sixth week to $1\frac{1}{3}$ lb. of fish-meal and $2\frac{2}{3}$ lb. of crushed oats, as against 2 lb. of decorticated cotton-cake and 2 lb. of crushed oats.

The total amount of protein contained in the concentrates fed to each animal in Groups III. and IV. was as follows:—

GROUP III.

1½ lb. decorticated cotton-cake supplied	0·60 lb. protein
1½ lb. crushed oats supplied . . .	·14 lb. „
Total . .	·74 lb. protein

GROUP IV.

1 lb. fish-meal supplied	·56 lb. protein
2 lb. crushed oats supplied . . .	·18 lb. „
Total . .	·74 lb. protein

The amounts of protein supplied by the two rations were thus equal, and the increase in the allowance of concentrates to the quantities already stated did not make any difference in that respect, as the proportions were not altered.

The full scheme for the experiment was thus as follows:—

Group I. 72 lb. swedes, straw and water *ad lib.*

„ II. 6 lb. hay, 72 lb. swedes, straw and water *ad lib.*

„ III. 3 lb. concentrates, rising to 4 lb. (One-half decorticated cotton-cake and one-half crushed oats.) 6 lb. hay, 72 lb. swedes, straw and water *ad lib.*

„ IV. 3 lb. concentrates, rising to 4 lb. (One-third fish-meal and two-thirds crushed oats.) 6 lb. hay, 72 lb. swedes, straw and water *ad lib.*

The experiment was continued for a period of twelve weeks, but the results given in respect of Group IV. are for a period of eight weeks only, as the animals in that group took a little time to get fully accustomed to their ration. This was no doubt due, in part at least, to the fact that the fish-meal fed to the animals was not just of the very best quality, and consequently the mixture of fish-meal and crushed oats was not particularly appetising. As soon as the animals were thoroughly accustomed to this food they seemed to acquire a special liking for it, and they could be seen licking out the troughs in which it had been fed.

It was also noticed that this lot of cattle drank more water than the others; but though this was quite apparent to the attendant, it was not possible actually to measure the amount consumed, and show by what quantity this exceeded the amount taken by the animals on the other rations. No doubt the slightly salty flavour associated with the fish-meal would be responsible for the greater desire for water on the part of the animals consuming it. At the same time the actual amount of

salt present in the meal would be equivalent to well under one ounce per animal per day.

The average live-weights of the animals in each group at the beginning and end of the experiment, as well as the total and average weekly gains, are given below.

TABLE III.

Group.	Ration.	Average live-weight at—			Average increase in live-weight.	Average weekly increase.
		Beginning of experiment.	End of four weeks.	End of experiment.		
		cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	lb.
I.	Swedes and straw . .	5 3 24	6 1 20	6 3 13	0 3 17	8·4
II.	Swedes, straw, and hay . .	5 2 0	6 0 5	6 2 19	1 0 19	11
III.	Swedes, straw, hay, oats, cake .	5 3 22	6 3 3	7 3 10	1 3 16	17·6
IV.	Swedes, straw, hay, oats, fish-meal . .	... ...	7 0 27	8 2 5	1 1 6	18·2

In considering these results, it should perhaps be pointed out that a direct comparison between Groups III. and IV. would not be quite a fair one. In the first place, the animals in Group IV. were rather heavier than the others, and thus were a little nearer maturity at the commencement of the experiment; then, owing to the fact that they took some time to get thoroughly accustomed to their ration, reliable figures are only available for a period of eight weeks as against twelve weeks; and it is well known that the longer the period over which reliable figures can be obtained, the more valuable will be the result. At the same time, the progress made by the animals, as measured by the average weekly increases recorded, and their condition when the experiment was concluded, was all that could be desired. They were well fleshed, they handled particularly well, they had the appearance of cattle that were making excellent progress, and they were nearer the prime condition than any of the others.

The results from the other three rations are exactly along the lines of those recorded in the previous year, for the differences due to the feeding were again very pronounced, both as regards weight and condition of the animals.

Those in Group I. had made quite good progress as regards growth, but they were still in rather a lean condition; they were also somewhat hard-looking, and had not the thriving appearance that stock-feeders like to see.

The animals in Group II. had not only grown considerably, but they had put on a fair amount of flesh and were much further forward than those in Group I., the actual difference in condition and appearance being more pronounced than the average weekly increases of 11 lb. and 8·4 lb. would lead one to expect. This was entirely due to one animal in Group II. not making such good progress as the others, and thereby lowering the average rate of increase. At the same time, it was very evident that the addition of 6 lb. ryegrass and clover hay effected a great improvement on the ration of swedes and straw.

As in the former experiment, however, the addition of the concentrates (decorticated cotton-cake and crushed oats) had again a most marked effect on rate of progress and on condition. Though the average live-weight per animal in this group at the commencement of the experiment was almost identical with that of the animals in Group I., there was, after twelve weeks' feeding, a difference of practically 1 cwt. Not only so, but all of the animals in Group III. were sufficiently well fleshed to furnish good beef, while those in Group I. were still in a lean condition.

The results again emphasise the difficulty, when dealing with growing animals, of producing beef without concentrates. They show the benefits from the addition of good ryegrass and clover hay to a ration of swedes and straw. They demonstrate very forcibly the still greater benefits from the inclusion of concentrates consisting of decorticated cotton-cake and crushed oats in such a ration; and they show that the replacing of decorticated cotton-cake and crushed oats with fish-meal and crushed oats, supplying the same total amount of protein, is not likely to materially affect the result.

It must be conceded that there was, and still is, in this country, a good deal of prejudice against the use of fish-meal as a feeding-stuff; and that is not to be wondered at, though the grounds for prejudice no longer exist. When feeding-stuffs were plentiful, fish-meal, as has already been pointed out, was only used to a very small extent in this country. The best customers for it were on the Continent, and when there are goods of different qualities, naturally the best customers get the best; other customers are supplied with what remains. That was pretty much the position as regards

fish-meal prior to 1914, and a considerable amount of what we did use was inferior in quality, and utilised not for stock-feeding, but as a manure; accordingly, we were not accustomed to look on fish-meal as a valuable feeding-stuff.

The prejudice against the use of fish-meal as a feeding-stuff, while it was materially lessened during the time of scarcity arising out of war conditions, was not by any means entirely swept away. Owing to this scarcity of feeding-stuffs, much fish-meal of an inferior type, with an offensive smell, and fit only for use as a manure, was sold as a feeding-stuff. Some farmers who gave it a trial for the first time, and were supplied with meal of the type referred to, were thankful when they had seen the last of it, and their experience was certainly not such as to encourage them to give it a further trial.

When unwholesome material, such as decaying fish or rancid fish, is used in the making of fish-meal, the resulting product is also unwholesome; it has an objectionable smell, and is fit only for use as manure.

Meals of this type are not at all suitable for stock feeding, and if used for that purpose they are likely to impart objectionable flavours to such resulting products as meat, eggs, milk, butter, cheese, &c., and may even interfere with the general health of the stock.

At the present day, however, there is practically no risk of being supplied with an inferior quality of fish-meal if ordinary care is exercised in purchasing, as the Association of Fish Meal, Fish Guano, and Fish Oil Manufacturers have now agreed as to a standard of quality for fish-meal for use as a feeding-stuff. The meal is called White Fish Meal, it is manufactured from white fish only and offals therefrom (heads, &c.), and in composition it conforms to the following limits:—

Protein, not less than . . .	55 per cent.
Phosphate of lime, not less than .	16 ,,
Oil, not more than	5 ,,
Salt, not more than	4 ,,

A wholesome, easily digested food of this standard in quality is certainly one with great possibilities associated with it, as apart from the actual food units it supplies, it will prove specially valuable for balancing up rations, consisting in the main of bulky home-grown foods, poor in protein, but rich in carbohydrates.

We are large importers of feeding-stuffs, and in view thereof, we will surely not allow this home product to be again shipped to the Continent without giving it a fair trial for all classes

of stock. If we do give it a trial, insist on guarantees in purchasing, and use it *in moderation*, the final result will never be in doubt.

Third Experiment.

The third and fourth experiments were carried out at the College Farm, Kilmarnock—the one late in the winter of 1918-19, and the other in the following winter, 1919-20.

In both of these experiments the chief aim in view was to obtain further information as to the value of fish-meal for beef production, as the results of the experiment carried out at the Crichton Farm, Dumfries, had been full of promise.

For the 1918-19 experiment twelve cattle were employed. These were dishorned Shorthorn crosses of a good useful sort and fairly even.

They were divided into two groups with six animals in each, and every effort was made to have the groups as equal as possible from every point of view.

The rations fed were more complex than those previously employed, but the one included fish-meal and the other decorticated earth-nut cake. Decorticated cotton-cake would have been preferred, as it is rather better known than the earth-nut cake, and in all the trials carried out by the College it had proved a useful and very reliable feeding-stuff, but there was none available at the time the experiment commenced.

The earth-nut cake is similar to the cotton-cake in many respects, but is even richer in protein, and in tests carried out by the College on the feeding of dairy cows, it had given results not only equal to, but actually a little better than those obtained from the use of decorticated cotton-cake.

The bullocks were housed in one large building containing six separate loose boxes, two animals being put in each. Each loose box was provided with water, and this the animals had access to at all times. Every loose box was also provided with separate feeding-troughs, so that each animal might get its due share of concentrates and of roots: there was also a rack in which the fodder was fed.

The rations fed to the two groups of cattle were as follows:—

Group I.

1½ lb. decorticated earth-nut cake.	Experimental part of ration.
2½ lb. crushed oats.	
2 lb. linseed-cake.	Basal part of ration.
72 lb. swedes.	
7 lb. hay.	
Straw *ad lib.*	

GROUP II.

1⅓ lb. fish-meal.	Experimental part of ration.
2⅔ lb. crushed oats.	
2 lb. linseed cake.	Basal part of ration.
72 lb. swedes.	
7 lb. hay.	
Straw *ad lib.*	

The quantities of decorticated earth-nut cake and crushed oats, and of fish-meal and crushed oats, were arranged in such a way as to supply approximately the same amounts of protein to the two groups of cattle.

The experiment did not begin just when the animals had been put on to the rations to be tested, but about a week was allowed to elapse, so that they might get accustomed to the rations before the experiment actually started.

The cattle took quickly to the different rations. Those in Group I. cleaned up the decorticated earth-nut cake and crushed oats right away, and in a very short time the animals in Group II. were taking the fish-meal and crushed oats equally well, and they could be seen licking out the troughs in which it had been fed. It was quite noticeable in this experiment, as it had been in the former one, that the cattle getting fish-meal drank more water than the others.

Through the courtesy of Messrs Donald, auctioneers, Kilmarnock, both the preliminary weighings and all subsequent weighings took place on the auction-mart weigh-bridge. It had been found from former experience that this method of weighing had many advantages; moreover, the special facilities at the market for the weighing of cattle more than compensated for any drawback which the walk of about half a mile to the market entailed.

The progress made by both groups of cattle was quite good, and there was little difference apparent. What difference there was, was rather in favour of the fish-meal ration, and furnished further proof of its value as a feeding-stuff.

The average live-weights of the cattle in each group at the beginning and end of the experiment, as well as the total and average weekly gains, are given below in Table IV., while Table V. gives the individual weights and the increase in weight made by each animal.

TABLE IV.

Group.	Ration.	Average live-weight at—						Increase in live-weight.			Average weekly increase.
		Beginning of experiment.			End of experiment.						
		cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.	lb.
I.	Earth-nut cake .	7	0	5	8	2	14	1	2	9	14·7
II.	Fish-meal . .	7	0	2	8	2	16	1	2	14	15·1

TABLE V.

GROUP I.—EARTH-NUT CAKE.

Animal No.	Live-weight at—						Live-weight increase.		
	Beginning of experiment.			End of experiment.					
	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.
1	7	0	14	8	2	14	1	2	0
2	6	2	0	8	0	14	1	2	14
3	8	0	0	9	3	14	1	3	14
4	6	1	0	7	3	0	1	2	0
5	6	0	14	7	3	14	1	3	0
6	8	1	0	9	2	0	1	1	0
Totals .	42	1	0	51	3	0	9	2	0

GROUP II.—FISH-MEAL.

Animal No.	Live-weight at—						Live-weight increase.		
	Beginning of experiment.			End of experiment.					
	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.
7	6	2	0	8	3	0	2	1	0
8	6	3	14	8	1	0	1	1	14
9	7	2	14	9	0	0	1	1	14
10	6	1	14	7	3	14	1	2	0
11	6	3	0	8	0	14	1	1	14
12	8	0	0	9	3	14	1	3	14
Totals .	42	0	14	51	3	14	9	3	0

It will be seen that there was very little difference in the results from the two rations, but that what difference there was favoured the fish-meal ration.

There is no need to go into the relative costs at this stage, but it should be pointed out that the fish-meal ration was the cheaper of the two by about one shilling per animal per week: when allowance is made for that, its superiority is more marked.

Fourth Experiment.

As has already been indicated, a still further experiment was carried out in the following winter, 1919-20, this also being undertaken at the College Farm. The object in view was the same as in the third experiment—namely, to further test the value of fish-meal for beef production.

This experiment was on practically the same lines as the previous one, with the exception that decorticated earth-nut cake was replaced with decorticated cotton-cake, but as the latter cake is not quite so rich in protein, a slightly larger amount was required in order that both rations might supply the same amount of protein. The daily allowance of hay was also decreased by 2 lb., as the supply available for the experiment was scarcely sufficient to permit of the larger amount being fed.

For the experiment there were 20 bullocks available. These were mostly blue-greys (Shorthorn Galloway crosses), but a few were almost pure Galloways, and showed distinct Galloway character. Altogether they were a very fine level lot, and just the right type for an experiment of the kind.

They were divided into two groups, with ten animals in each, and every care was taken to make the groups as uniform as possible in every way. They were housed in loose boxes as in the former experiment, and had access to water.

The experiment was continued for a period of 110 days, so as to better bring out any differences due to the feeding. The actual rations fed to the two lots of cattle were as follows:—

Group I.

2 lb. decorticated cotton-cake.	Experimental part of ration.
2 lb. crushed oats.	
2 lb linseed-cake.	Basal part of ration.
72 lb. swedes.	
5 lb. hay.	
Straw *ad lib.*	

GROUP II.

1⅓ lb. fish-meal. 2⅔ lb. crushed oats.	Experimental part of ration.
2 lb. linseed-cake. 72 lb. swedes. 5 lb. hay. Straw *ad lib.*	Basal part of ration.

At the end of the sixth week of the experiment the allowance of concentrates, including the linseed-cake, was increased by 1 lb. per head per day, but the proportions fed remained the same.

Both groups of cattle took quickly to their rations, and at the outset they made very marked progress.

As the experiment progressed and the animals got nearer to the "prime" stage, the rate of increase fell materially, but at the end of the experiment almost all of the animals were particularly well finished; and as it is a well-established fact that cattle near the prime stage do not show the same rate of increase as those not so far forward, this falling-off at the end can be fully explained on that ground.

During the experiment it was again apparent that the fish-meal created a greater desire for water, and the cattle on that ration drank more than those getting decorticated cotton-cake.

Table VI. below gives particulars of the average live-weights of the animals in each group at the beginning and end of the experiment as well as the total and the average weekly increases, while Table VII. gives the figures for the individual animals.

TABLE VI.

Group.	Ration.	Average live-weight at—						Average increase in live-weight.			Average weekly increase.
		Beginning of experiment.			End of experiment.						
		cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.	lb.
I.	Decorticated cotton-cake	7	0	24	9	1	13	2	0	17	15·3
II.	Fish-meal .	7	0	22	9	1	16	2	0	22	15·6

TABLE VII.

Group I.—Decorticated Cotton-Cake.

Animal No.	Live-weight at—						Increase in live-weight.		
	Beginning of experiment.			End of experiment.					
	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.
1	7	0	0	9	0	0	2	0	0
2	7	1	0	9	2	0	2	1	0
3	8	1	0	10	2	14	2	1	14
4	7	0	14	9	1	14	2	1	0
5	7	0	0	8	1	14	1	1	14
6	7	0	14	9	0	0	1	3	14
7	7	0	0	8	3	14	1	3	14
8	6	1	0	8	0	14	1	3	14
9	7	0	14	10	3	0	3	2	14
10	8	0	0	10	0	0	2	0	0
Totals .	72	0	14	93	2	14	21	2	0

Group II.—Fish-Meal.

Animal No.	Live-weight at—						Increase in live-weight.		
	Beginning of experiment.			End of experiment.					
	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.
11	7	1	0	9	3	14	2	2	14
12	7	0	14	9	1	14	2	1	0
13	7	0	14	9	0	14	2	0	0
14	7	1	0	10	0	14	2	3	14
15	7	0	14	9	0	14	2	0	0
16	7	1	0	9	1	14	2	0	14
17	7	1	14	9	2	14	2	1	0
18	7	1	0	9	1	0	2	0	0
19	7	0	14	8	2	0	1	1	14
20	7	0	14	9	2	0	2	1	14
Totals .	72	0	0	93	3	14	21	3	14

It will be seen from the above table that the progress made by the animals in each group was very uniform, with the exception of two animals in Group I., Numbers 5 and 9, the former being considerably below the average and the latter very much above it, and of one animal in Group II., No. 19, which was below the average.

At the end of the experiment the cattle were slaughtered

and sold on the dead-weight basis, and it was therefore possible to get the carcase-weight for each animal and ascertain the effect of the rations not only on live-weight but also on carcase-weight There was not much differencc in the two groups in this respect, but this time the difference was rather in favour of the decorticated cotton-cake ration, as the percentage of carcase-weight to unfasted live-weight was rather higher for the animals on that ration than for those on fish-meal.

This may have been due to the fact that the cattle in the first group did not take so much water.

Full particulars are given below.

TABLE VIII.

GROUP I.—DECORTICATED COTTON-CAKE.

Animal No.	Unfasted live-weight.			Carcase-weight.			Per cent carcase-weight to live-weight.
	cwt.	qr.	lb.	cwt.	qr.	lb.	
1	9	0	0	5	0	16	57·1
2	9	2	0	5	1	12	56·4
3	10	2	14	6	0	22	58·3
4	9	1	14	5	1	3	56·3
5	8	1	14	5	0	0	59·7
6	9	0	0	5	0	2	55·7
7	8	3	14	5	0	9	57·2
8	8	0	14	4	2	24	58
9	10	3	0	5	3	24	55·4
10	10	0	0	5	3	22	59·4
Totals .	93	2	14	53	2	22	Average 57·3

GROUP II.—FISH-MEAL.

Animal No.	Unfasted live-weight.			Carcase-weight.			Per cent carcase-weight to live-weight.
	cwt.	qr.	lb.	cwt.	qr.	lb.	
11	9	3	14	5	1	21	54·1
12	9	1	14	5	1	4	56·4
13	9	0	14	5	1	20	59·5
14	10	0	14	5	3	4	57·1
15	9	0	14	5	1	10	58·5
16	9	1	14	5	1	1	56
17	9	2	14	5	1	5	55
18	9	1	0	5	0	18	55·8
19	8	2	0	4	3	13	57·2
20	9	2	0	5	0	7	53·3
Totals .	93	3	14	52	3	19	Average 56·4

It will be seen from the above table that there was comparatively little variation in the percentage of carcase-weight to *unfasted* live-weight, the actual variation in the case of Group I. being from 55·4 per cent to 59·7 per cent, and in the case of Group II. 53·3 per cent to 59·5 per cent. The percentages of carcase-weight to live-weight are very satisfactory, especially as the average live-weight was just a little over $9\frac{1}{4}$ cwt., and also in view of the fact that the live-weights were taken before the animals had been fasted. If they had been fasted the percentages of carcase- to live-weight would have been very much higher, and certainly not less than 60 per cent.

In view of the fact that fish-meal was very often blamed for tainting the produce, a report on the quality of the flesh was obtained from a Kilmarnock butcher, who was supplied with a carcase from the fish-meal lot. The report was a very favourable one, and was as follows: "*The carcase was an excellent one, perhaps the best I have handled this year. No undue predominance of fat over lean, well fleshed and well finished; the colour was excellent. From a butcher's point of view, an excellent carcase. All of my customers who were served with this beef were extremely well pleased.*"

The opinion of a consumer was also obtained, and he reported that there was no taint whatsoever apparent, and endorsed what was said by the butcher regarding the high quality of the meat. It would therefore seem that the quality of the meat from the fish-meal ration was all that could be desired.

One other aspect of this experiment still remains to be considered—namely, the relative costs of the rations fed to the two groups of cattle. Since the actual differences in the results obtained from their use have been so small, the costs at which these results were obtained assume all the greater importance, for if two different feeding-stuffs can be relied on to give similar results, and if there is a difference in their price, the stock-feeder is standing badly in his own light if he does not use the cheaper one.

The prices of the various feeding-stuffs change from time to time according to supply and demand, freights, &c., but the actual prices prevailing for the linseed and decorticated cotton-cake and for the fish-meal at the time the experiment commenced were as follows:—

Linseed-cake	£26 per ton
Decorticated cotton-cake . . .	£26 „
Fish-meal	£18 „

Taking current market values for the home-grown foodstuffs used in the experiment into account, the following represent fair prices to assign to these:—

Crushed oats	£19 per ton
Turnips	30s. „
Ryegrass and clover hay . . .	£12 „
Oat straw	£4 „

If we apply these figures, we find that the average weekly cost of the ration, which included decorticated cotton-cake, amounted to 22s. 9d. per head, and that the cost of the one containing fish-meal amounted to 21s. 8d. per head, the actual difference in favour of the latter ration thus being 1s. 1d. per animal per week, or approximately 17s. per animal for the duration of the experiment. At the prices ruling at the time the experiment was conducted, the fish-meal ration was therefore the cheaper of the two.

Table IX. gives a summary of the particulars of the experiments that have been dealt with in this report.

[Table IX.

TABLE IX.

Experiment No.	Centre at which conducted.	Particulars of daily rations fed—								Duration of experiment.	Number of animals employed.	Average live-weight at—						Average weekly increase.
		Swedes.	Hay.	Straw.	Oats.	Fish-meal.	Linseed-cake.	Decorticated cake.				Beginning of experiment.			End of experiment.			
								Cotton.	Earth-nut.									
		lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	weeks.		cwt.	qr.	lb.	cwt.	qr.	lb.	lb.
1	Crichton Farm, Dumfries	72	...	24	...	...	...	...	...	13	6	6	2	10	7	3	12	10·9
2	„	72	6	16	...	...	...	...	...	13	6	6	2	11	8	1	2	14·4
3	„	72	6	8	1½-2	...	...	1½-2	...	13	6	6	2	13	8	3	19	19·8
1*a*	„	72	...	24	...	...	...	...	...	12	3	5	3	24	6	3	13	8·4
2*a*	„	72	6	16	...	...	...	...	...	12	3	5	2	0	6	2	19	11·0
3*a*	„	72	6	8	1½-2	...	...	1½-2	...	12	3	5	3	22	7	3	10	17·6
4	„	72	6	8	2-2⅔	1-1⅓	...	...	...	8	6	7	0	27	8	2	5	18·2
5	College Farm, Kilmarnock	72	7	8	2½	...	2	...	1½	12	6	7	0	5	8	2	14	14·7
6	„	72	7	8	2⅔	1⅓	2	...	...	12	6	7	0	2	8	2	16	15·1
7	„	72	5	12	2	...	2	2	...	15½	10	7	0	24	9	1	13	15·3
8	„	72	5	12	2⅔	1⅓	2	...	...	15½	10	7	0	22	9	1	16	15·6

Conclusions.

The following conclusions may be drawn from the foregoing experiments:—

Young growing cattle cannot, in a normal feeding period, be fattened on a ration consisting of straw and turnips, though they may materially increase in weight on such a ration.

The addition of good ryegrass and clover hay effects a marked improvement in a ration consisting of straw and turnips, and by prolonging the feeding period even young growing cattle will on such a ration put on enough flesh to make them fit for beef. It does not follow, however, that this method of feeding is an economical one.

The addition of concentrates, consisting of crushed oats and decorticated cotton-cake in equal amounts, to a ration consisting of turnips, hay, and straw, effects great economy in the consumption of these foods per 100 lb. live-weight increase, and enables even young growing cattle to be fattened in a relatively short time.

If care is taken to secure genuine white-fish meal, it will be found to be a wholesome and valuable food for fattening cattle, and if fed in quantities similar to those given in the experiments very good results will attend its use.

If fish-meal is fed in mixture with crushed oats, cattle soon get accustomed to it and acquire a liking for it.

Cattle getting fish-meal in their ration will, if they have access to water, drink more than if they were fed on a ration which does not contain fish-meal.

Fish-meal, in conjunction with crushed oats, may be relied on to give results at least equal to those obtained from decorticated cotton-cake and crushed oats or decorticated earth-nut cake and crushed oats, and at a lower cost.

Fish-meal of the kind described, and fed in the quantities and in the manner indicated, will have no detrimental effect on the quality of the flesh, or impart any flavour thereto.

In conclusion, the writer desires to express his great indebtedness to Mr Will of the Crichton Farm, Dumfries, to Mr Gillies, "Homelea," Thornhill, County Instructor for Dumfriesshire, and to Mr James Cochrane, Superintendent of Experiments, College Farm, Kilmarnock, for the very practical and valuable help they gave in arranging and carrying out the experiments.

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West of Scotland Agricultural College.

BUTTER-MAKING ON THE FARM.

BY

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PROFESSOR OF DAIRYING.

SYNOPSIS OF PROCESS.

1. Take special precautions to produce a clean high-grade milk.

2. Separate the new milk while still warm, and never below 80° F.

3. Pasteurise the cream (150° F. for 20 minutes in the case of fresh or powdered butter, or 160°-180° F. for 10 minutes for salt or potted butter).

4. Ripen at the correct temperature to a medium degree of acidity with a good starter.

5. If necessary chill the ripened cream for 2-3 hours before churning.

6. Churn at a suitable temperature (57° F. a mean) to the size of wheat grains.

7. Wash the granular butter with pure water and brine for 15 minutes.

8. Work the butter mass till sufficiently dry.

9. Salt, if necessary, at the right stage, and make up the butter into suitable packages.

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BUTTER-MAKING ON THE FARM.

BUTTER-MAKING is a less complicated process than cheese-making. The systematic operations are relatively simple; the time-factor does not exercise the same controlling influence as it does in the making of cheese; no curing period is required before the finished product is ready for consumption; the method of packing and storage presents no insuperable difficulties. Yet despite the comparative simplicity of the method of manufacture, the amount of really first-class butter that finds its way into the home market is small. The bulk of our farm butter, especially the so-called fresh butter, is only second class: much of it is actually bad. Three reasons may be adduced for this: (*a*) by its nature butter is a perishable article of food, and unless special care is taken in its manufacture it will quickly develop taints and become rancid; (*b*) the average butter-maker does not yet appreciate the fundamental principles which determine the production of a high-grade article; (*c*) for the past decade butter-making on the farm has been less remunerative than either cheese-making or milk-selling, and there has consequently been little incentive towards improvement.

PRODUCTION OF PURE MILK.

The flavour and keeping properties of butter are largely dependent on the purity of the milk supply. The very best quality of butter can only be made from the milk of healthy cows which is produced under scrupulously clean conditions. It is wrong to suppose that, because pasteurisation is now a recognised part of the routine of butter-making, no special precautions need be taken with the milk supply. The very organisms which are unaffected by pasteurisation, *e.g.*, spore-bearing gas producers, are those which often give rise to bad

flavours in butter. Good raw material in the form of pure milk is the primary requisite of the butter-maker, but to obtain pure milk is far more difficult than one might imagine. To know what are the main sources of contamination in the milk, and to eliminate these so far as is possible, are the first steps towards the production of a high-grade butter. Attention to the following points will be helpful.

(*a*) *Ventilation of the Byre.*

The air of the byre should always be fresh and sweet, and never oppressive. This can only be secured by a sufficient

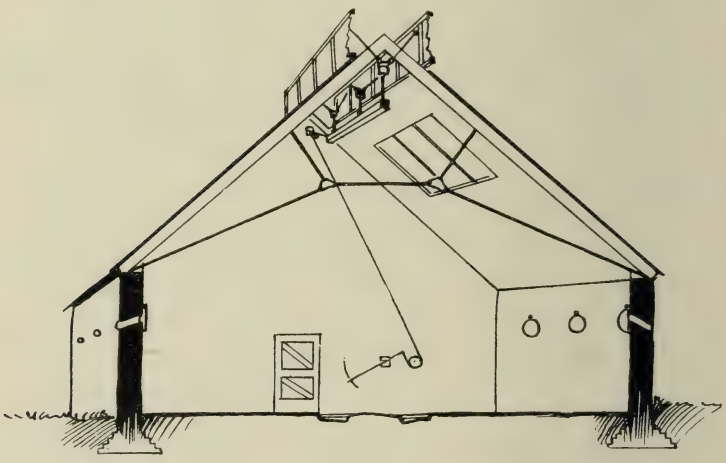


Fig. 1.

Isometric Section through Byre, showing open frame roof supports, lighting and ventilation arrangements. Stall partitions omitted.

cubic air space and by a suitable system of ventilation. The ingress of fresh air through controllable inlet tubes in the walls (Barr's system) and the exit of foul air by the ridge-roof ventilator (Findlay system) will allow of the atmosphere of the cowshed being continuously renewed without incurring draughts. A close stuffy atmosphere argues defective ventilation, and in a byre where such conditions prevail it is difficult to produce a pure milk, because the stagnant atmosphere is heavily laden with hostile germs.

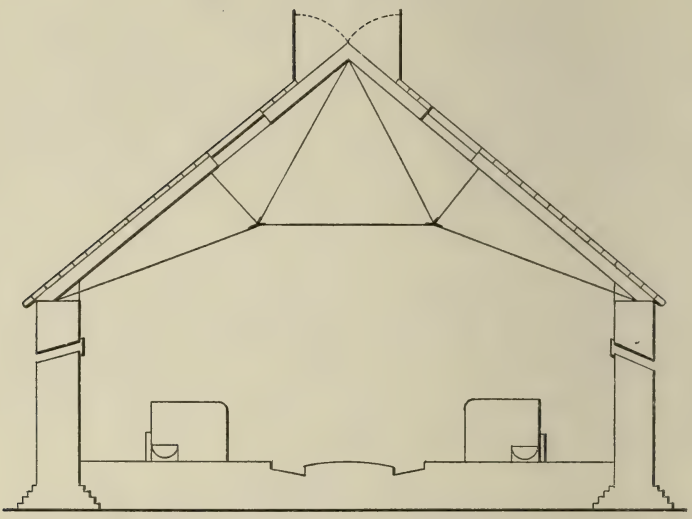
(*b*) *Lighting of the Byre*

The whole interior of the byre should be flooded with light. This is best effected by roof-lights of ample dimensions, preferably in the form of large oblong panes of frosted glass, inset at successive intervals right along each slope of the roof. The majority of byres are much too dark. The more the light of day illumines the byre, the lower will be the germ-content and the better the prospect of producing a purer milk. The comparative darkness of the gloomy winter day and the restricted lighting arrangements of the average byre are favourable to germ life. This is one of the reasons why winter milk usually contains bacteria of a highly undesirable type. Sunlight is the best and cheapest germicide; darkness and disease go hand in hand.

(*c*) *Hygienic Condition of Byre.*

The sanitary condition of the byre calls for careful attention. An ill-kept byre, the atmosphere of which is invariably polluted, is one of the prime causes of taints in milk. Butter made from such raw material is certain to develop objectionable flavours, especially in the fresh or lightly-salted condition; even heavy salting will not entirely suppress their development. It is possible, though difficult, to produce good milk in a byre the floor of which is rough and ill to keep clean. The floor should be made of some impervious material the surface of which is moderately smooth and easily washed. If the surface is so smooth as to be slippery for the cows, especially when it is wet, a sprinkling of clean sand will give the necessary foothold. The central passage must be sufficiently broad (5-6 feet); all corners and angles between the floor and walls should be rounded off. Under such conditions the labour of keeping the byre in the necessary condition of cleanliness will be materially lessened. The manure channel should be 2 feet wide, with a slope of half-an-inch towards the central passage so as to run off quickly the fluid excrement.

No traps or closed drains within the byre should be tolerated; all liquids should be conducted by open channels to the outside of the byre before being discharged into a sewage



Scale $\frac{1}{12}$ inch to 1 foot

FIG. 2.

Cross Section of Byre, showing feeding passages, roof supports, and Findlay Ventilator.

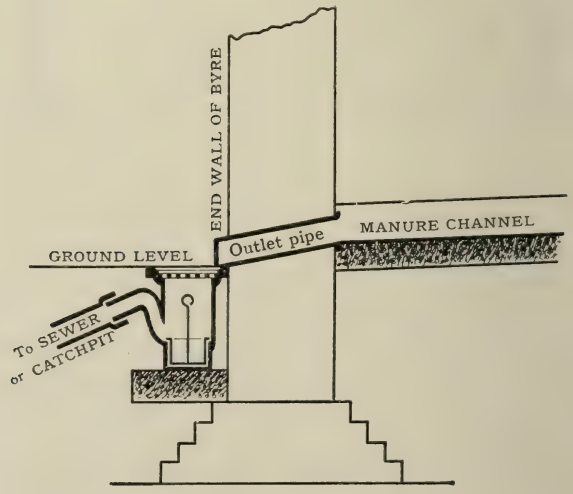


FIG. 2A.

Method of Dealing with Sewage as it leaves the Byre.

pipe. To prevent the back suction of sewer gases the drain should be trapped outside the byre just where it begins its course.

In the winter-time, when the cows are housed inside, the byre should be washed daily with plenty of water. The mangers in particular must be kept clean. The manure should be removed twice daily, but never just before milking. The contamination of the atmosphere at this time must be avoided at all costs.

The inner wall of the byre, to a height of 6 feet from the floor, should have a smooth cement surface. If in addition the surface is coated with a cement-like enamel paint it is capable of being easily washed and disinfected. The best and cheapest germicides for this purpose are blue-stone, formalin, and chloride of lime. Formalin is perhaps the safest and most reliable. Above the cement facing of the wall the surface should be limewashed at least twice a year.

Occasionally the byre should be fumigated, and always after an outbreak of contagious disease. Sulphur and formalin are both effective fumigants. Liquid sulphur dioxide may also be used, but its employment demands some care.

The presence of flies in the byre in summer-time is inimical to the production of pure milk. Not only do they spread disease themselves, but the violent switching of the cows' tails which they induce causes showers of fecal organisms to fall into the milk pail. A fly plague in the byre is often due to the presence of an adjacent manure heap, draff pit, or other fermenting mass, where they breed. To keep down flies in the byre, remove any possible breeding places; suspend fly-paper or adhesive string in the cowshed; or use poisoned baits. Of the latter the two most effective are (*a*) watery milk, containing formalin (15 parts formalin, 20 parts milk, 65 parts water); (*b*) castor oil with a trace of croton oil (1 oz. castor oil and 2 drops croton oil). These baits should be set out in shallow trays on the wall plates or supporting beams of the roof.

Fumigation with formalin will also prove helpful in suppressing flies.

(*d*) *Grooming and Cleaning the Cow.*

Perhaps the greatest source of contamination during the milking period is the cow's coat. Fully 60 per cent. of the total contamination is traceable to this source, and the germs of this origin are the worst possible type from the butter-maker's point of view. Hence during winter the cows should be groomed daily. The hair on the flanks and udder should be kept short, but the cruel practice—which is now, happily, almost obsolete—of singeing the hair on the vessel cannot be too strongly condemned. The hair on the tail should be cut so that the brush is well above the ground. In the winter-time the stall, especially the part adjacent to the grip, must be kept clean, otherwise the soiling of the cow's coat by the manure droppings is unavoidable. To promote cleanliness plenty of clean litter should be employed and the flanks of the cows washed frequently. Good butter cannot possibly be made from the milk of cows on whose hind-quarters the manure from the stall has become caked and hardened.

(*e*) *Care in Feeding.*

Milking time demands the special attention of the butter-maker. To keep the air of the byre pure and to minimise the contamination of the milk, the feeding of bulky foods like hay and straw, either prior to or during milking, must be avoided. The carrying of such foods through the cowshed makes the air dusty and greatly increases the number of germs that fall into the milk-pail. Again, such germs are of a highly undesirable type, and are a common source of faulty milk and bad butter, especially where whole-milk butter is made and pasteurisation is not practised. Foddering should be done preferably after milking, or some considerable time in advance of it.

Some foods, if fed just before milking, tend to taint the milk. Turnips, cabbages, rape, silage, draff, rye, and root crops generally—except, perhaps, potatoes—come under this category. All such foods should be given after milking. The turnippy flavour which is so common in winter butter is not, however, invariably due to the feeding of turnips. It often

occurs where no turnips (or similar roots) are fed at all. In these cases the off-flavour is attributable to the activity of certain organisms the presence of which in the milk indicates lack of cleanliness.

(*f*) *Care in Milking.*

Just before milking begins the udder and flanks of the cow should be wiped with a clean damp cloth or sponge. This removes those particles of dust and dung which, falling into the milk-pail, constitute the worst source of all contamination in the milk. Whenever this practice has been adopted an immediate improvement in the flavour and keeping properties of the milk and the quality of the dairy produce is noticeable. This procedure is now invariably followed in all the best dairies.

The milker should be gentle and rapid at work, and should milk with clean dry hands. Wet milking is a dirty practice which cannot be too strongly deprecated. If the cow's teats are chapped, or have a roughened skin, a little vaseline may be used with benefit to prevent friction and irritation during milking. The fore-milk is highly contaminated and of poor quality, usually containing less than 1 per cent. of fat. Hence the first few streams from each teat should be rejected. On the other hand, the strippings are nearly germ-free, and have a high fat-content—usually about 10 per cent. If any milk has been left behind in the udder after milking has been completed the milk at the next period will always contain more bacteria and will have diminished keeping properties. This provides an additional reason for clean milking.

The milkers must be cleanly in person, and should be provided with clean white overalls. All persons having access to the cows should be healthy and free from contagious disease. Dairy workers who are apparently healthy but are shown to be bacillus carriers are a constant source of danger to the community.

The cow's tail should be kept still during milking.

The use of hooded milk-pails greatly lessens the initial contamination of the milk. Most of these pails, however, are of faulty construction; they are much too high for low-set

cows of the Ayrshire breed, so that the milker's hands constantly strike the rim of the hood. The principle, however, is sound, and when properly made and used these pails will reduce the initial contamination by 60 per cent. The follow-

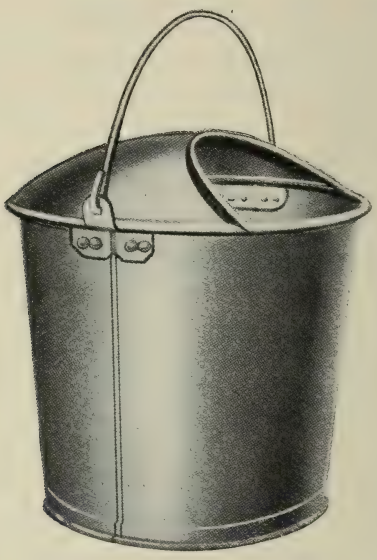


Fig. 3.
Hooded Milk Pail.

ing dimensions will be found suitable:—Diameter—top 11 inches, bottom 9 inches; height of pail to upper margin, 9 inches; height of hood above upper margin, $2\frac{1}{2}$ inches; size of opening, $8\frac{1}{2}$ inches by $5\frac{1}{2}$ inches.

Milking machines are now being more largely used on dairy farms, and, when properly managed, give satisfactory results. But special care has to be taken to keep the teat-cups and milk-tubes clean, otherwise the results so far as the purity of the milk supply is concerned may be even worse than hand milking performed under unhygienic conditions. Immediately after milking the metal parts of the machine, including the pail and the lid with its mechanical fittings, should be washed and effectively sterilised with boiling water or live steam. All rubber tubing and teat-cup linings should be cleaned and thoroughly sterilised after use by immersion

in cold water containing some formalin or hypochlorous acid. Rubber is exceedingly difficult to sterilise, and water alone—even hot water—will not render it germ-free. Good results have recently been obtained by keeping the rubber parts between the milkings in a 15 per cent. brine, or in a saturated brine solution to which some bleaching powder has been added, or even in pure running water. The success of the milking machine, not only as regards its efficacy, but also as regards the cleanliness of the milk, very largely depends on the skill of the operator. The amount of care required to produce clean milk is just as great where a machine is employed as when hand milking is practised.

(*g*) *Handling and Treatment of Milk.*

The milk, as soon as withdrawn from the cow, should be taken to the dairy or milk-house. If left standing exposed

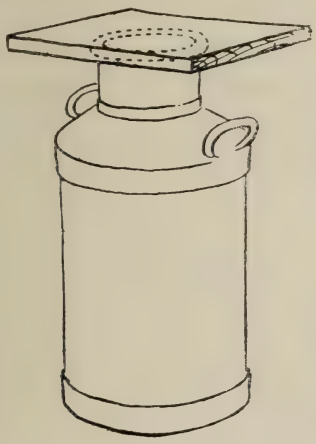


Fig. 4.
Milk Collecting Can, protected by Board.

in open collecting vessels in the byre during milking the amount of contamination it receives will be greatly increased, and the milk will be less suitable for the manufacture of dairy products. If for any reason it is not practicable to carry this into effect, then a clean board should be placed

over the mouth of the collecting can while it is being gradually filled. This simple device will be found a great advantage in improving the keeping properties of the milk.

The straining of the milk is an important consideration. An ordinary brass wire strainer keeps back only coarse particles, hairs, &c. It allows all the finer insoluble dirt to pass through. The efficiency of such a filter is considerably increased by fitting to it two or three plies of fine cheese-cloth previously sterilised in boiling water. The best results, however, are got from absorbent cotton-wool filters of the Diabolo or Ulax type. These filters will remove most of the visible dirt; they are sufficiently rapid to obviate clogging, and they are easily handled in the cleaning. Fresh cotton-wool discs should of course be used for each milking. But no type of filter, however efficient, will remove either the bacteria or the disagreeable flavours introduced by the soluble portion of the dirt. The latter cannot possibly be strained out, while bacteria are so very small that they easily pass through the meshes and pores of the finest filters. Accordingly, while careful straining improves the appearance of the milk by keeping out the visible dirt, it has little effect either on the bacterial content or the keeping properties of the milk. The only safe course is to prevent the admission of dirt and the associated bacteria.

(*h*) ***Condition of Utensils.***

All utensils which are brought into contact with the milk must be kept thoroughly clean. Wooden vessels, even when made of hard, close-grained wood, are more difficult to keep clean than tinned steel or enamel ware. All seams in steel utensils should be flushed with solder and the corners rounded off. The metallic surfaces must be kept smooth and bright. Rusty vessels should never be employed; they impart a bitter metallic taste to the milk and taint the butter made from it. Pasteurisation will not remedy this defect. After use dairy utensils should be washed with lukewarm water, then with boiling water, and, whenever possible, *sterilised with live steam*. This will ensure quick drying and prevent rusting.

(*i*) *Healthiness of Herd.*

It is necessary to add that the cows should be healthy and free from hereditary and contagious disease. The udders must be sound. Cows with affected udders cannot possibly produce hygienic milk. "Weed" or garget makes the milk unsuited for the production of a high-grade butter. Again, cows which have apparently recovered from a "weed" frequently give milk with a high bacterial count—much higher than normal. Such milk is liable to go wrong quickly, and is one of the commonest sources of faults in butter and cheese. All dairy cows should be tuberculin tested once a year and the reacters discarded. Cows with tuberculosis of the udder are a real danger, for unless the milk be pasteurised it is highly pathogenic. Butter, it may be remarked, can harbour the germs of tuberculosis in a virulent state for three months.

(*j*) *Water Supply.*

On the dairy farm, and particularly on a butter-making farm, an abundant supply of pure cold water is absolutely indispensable, both for stock and for dairy purposes. The keeping qualities of the butter are markedly influenced by the nature of the water supply. Hence for washing the utensils, and more especially for thinning the cream and washing the butter, none but the purest water should be used. It is of little use pasteurising the cream and using a pure culture starter if the water which is brought directly into contact with the cream and the granular butter is not bacteriologically pure. Deep well water or gravitation all water from a reliable source is most satisfactory. The surface drainage from arable fields or the run-off from roofs is quite unsuitable. If the water is at all suspicious, it should be purified either by a system of filtration through an earthenware filter (Doulton type) or by boiling and subsequently cooling the water. The former method is cheaper and generally more satisfactory.

If the butter-maker can only be made to realise how much these primary factors in milk production contribute to the

quality of the finished product, and, above all, if he can be induced to practice more than ordinary care in the production

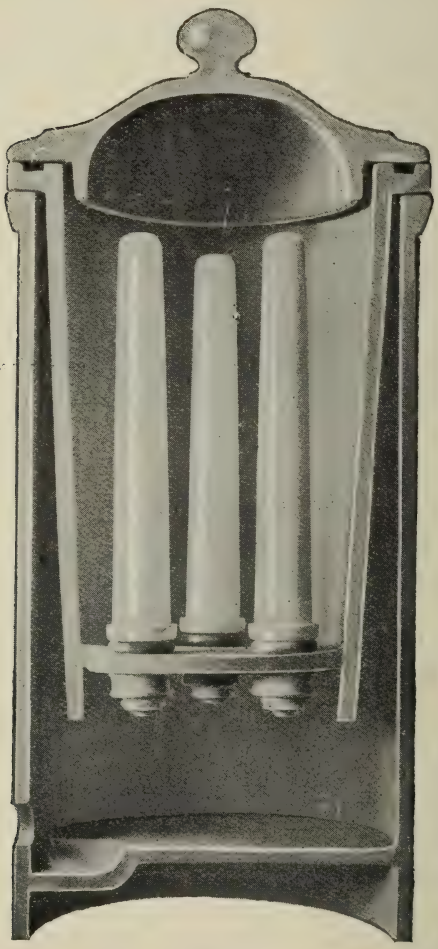


Fig. 4a.
Doulton Filter.

and handling of milk, he will have gone a long way towards complete success.

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Glasgow, ...

With the Compliments of the Principal.

PROCESS OF MANUFACTURE.

Butter may be made either from whole milk or from cream. The latter process, which will be described first, may be regarded as the standard method. It is invariably practised in dairy factories, and is now adopted by up-to-date dairymen, because it gives better financial returns. The manufacture of butter from whole milk, however, still finds favour in many rural districts of Scotland, and will be described in a later section.

Cream from which butter is made may be regarded simply as milk specially rich in butter-fat. It is composed of the same constituents as milk, but in different proportions. The following analysis is typical of cream adapted for churning :—

Fat, ...	30·00
Protein, ...	2·63
Sugar, ...	3·57
Ash, ...	0·57
Water, ...	63·23
	100·00

The butter-fat is present in the form of minute globules, which vary in size according to the breed of the cow, the period in the lactation, and to a certain extent with the feeding and the season of the year. The Jersey, Guernsey, and generally the beef breeds give large-sized fat globules, while those of the Ayrshire, Shorthorn, and Holstein are relatively small. The milk of newly-calved cows contains large globules, while that towards the end of the lactation shows small globules. The size of those globules has a close relationship to the rate of creaming under natural conditions, to the time of churning, and to the amount of fat in the butter-milk. The larger the globules, the quicker the cream formation, the easier is the churning, and the more complete the removal of the fat from the butter-milk.

Separation of Cream.

(1) *Gravity System.*

(*a*) *Shallow Setting.*—To separate cream from milk both natural and mechanical means are employed. Before the introduction of the separator the gravity method was universal; it is still used to quite a considerable extent in small dairies where the output of butter is limited. The

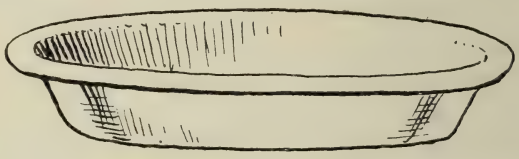

Fig. 5.

procedure simply consists in setting the milk to cream in special vessels called shallow pans or milk-plates, which are 18-24 inches in diameter, and from 4-6 inches deep. At the end of 24-36 hours the cream, which has risen to the surface, is removed by means of a special skimming dish.

To get the best results from this system the temperature of the milk-room should be well under 60° F., and the milk should be set in the plates directly it is withdrawn from the cow. The efficiency of the shallow pan method may be increased by heating the milk to 130° F. before setting it to cream. Thick shallow pan cream usually contains about 30 per cent. fat.

The space taken up by these pans in the dairy, the labour involved in cleaning them, and the time taken to obtain the cream are distinct objections to this system. The greatest drawback, however, is the loss of fat entailed. Under the best conditions about 0·5 per cent. fat is left behind in the skim, and in summer-time, when the temperature of the dairy is unavoidably high, the loss may reach 1 per cent. or even more.

(*b*) *Deep Setting.*—Better results are got from the deep-setting system. Here the warm new milk is put up in deep volumes, and during creaming is water-cooled. The Cooley Can and the Jersey Creamer are both adapted for this method.

The *Cooley Can* is a deep shot-gun vessel, holding 4-6 gallons and fitted with an over-lapping water-tight lid. Some Cooley Cans are provided with a glass gauge by which the depth of the cream layer may be measured, and a siphon-and-faucet pipe for running off the skim from below the cream.

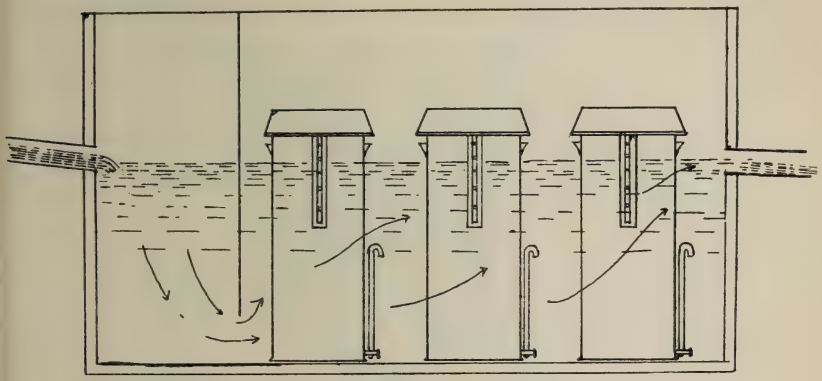

FIG. 6.
Cream Raising by Cooley Cans.

The cans are immersed in a current of cold water during the process of creaming. This method is quicker and more effective than the shallow pan; about 0·2 per cent. fat is left in the skim. The cream is obtained in 12 hours, and generally contains about 20 per cent. fat.

The *Jersey Creamer* is simply a double-jacketed vat (like a cheese vat), in the jacket of which cold water is constantly

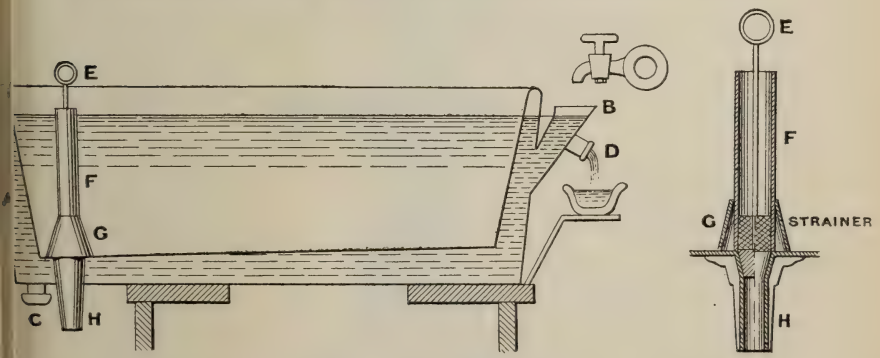

FIG. 7.
Section of Jersey Creamer (with lid removed), and enlarged Section of Plug.

, Double-cased Vessel. B, Water Inlet. C, Water Outlet. D, Water Overflow. E, Plug, fitting into pipe F, h is fitted at the bottom with a strainer of fine wire gauze, protected when in use by the ring G (which is vable). Pipe F rests within the fixed pipe H, through which the skim milk is drawn off.

circulated. The skim is drawn off by a hole in the bottom of the vat closed by a plug.

(*c*) *Water Dilution Method.*—An expedient which was formerly adopted in America for speeding up the rate of separation of the cream consisted in adding water to the milk at setting. The water, by diminishing the viscosity of the milk, enables the fat globules to rise quicker to the surface. This principle, known as the Water Dilution Method, has now been abandoned, because the skim is so diluted as to be practically useless, and because the cream is liable to more than the usual amount of contamination. The loss of fat is even greater than with the shallow pan.

(2) *Centrifugal System.*

Wherever butter is made on any considerable scale the foregoing methods of cream raising have been discarded in favour of the mechanical cream separator.

Advantages of Separator.—The separator has many advantages. It economises time and labour. A machine to separate

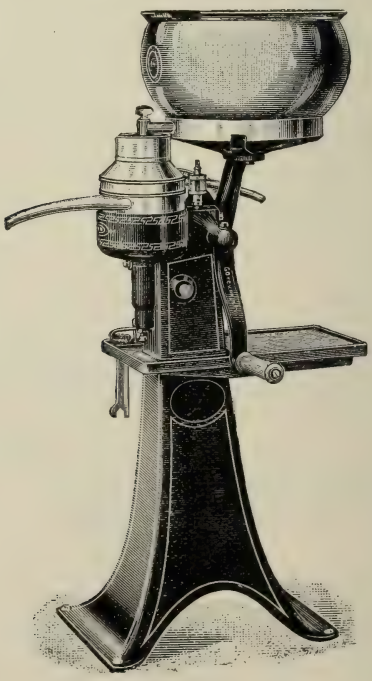

Fig. 8.

"Alpha Laval" Separator (Cream Screw)

60-90 gallons per hour can be manipulated by a single person. The shallow pan method, to separate the same amount of milk, would require 20 to 30 pans, and would take at least 24 hours to give the cream. The amount of space taken up by the separator would not be much more than that occupied by two such pans. Cream of any degree of richness is obtained

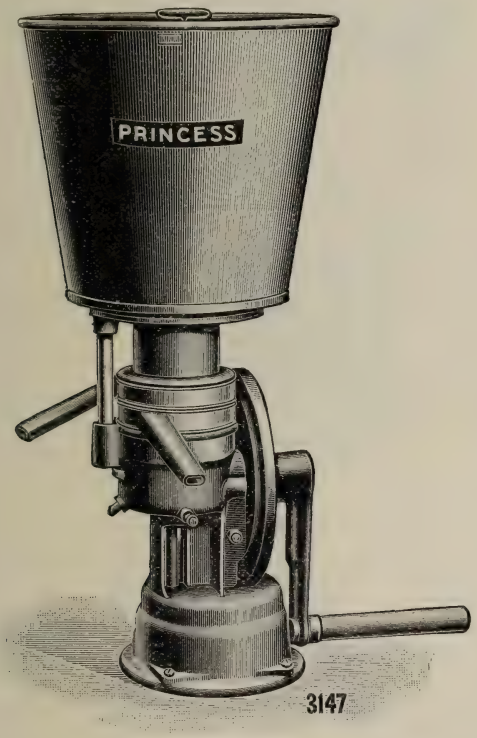

Fig. 8a.
"Princess" Separator (Skim Screw).
Made by Watson, Laidlaw & Co., Glasgow, S.

merely by altering the cream screw or skim screw. The cream is fresh and in good physical condition for subsequent treatment and manipulation. Many impurities originally present in the milk are removed, and a fresher and purer skim is returned. A wider range of temperatures for the separation process is practicable. But perhaps the greatest

advantage of the separator is its efficiency in removing the fat from the milk. A good hand-power separator should not leave more than 0·1 per cent. to 0·15 per cent. fat in the separated milk; many power-driven machines leave as little as 0·05 per cent. fat. There is thus a clear gain of at least

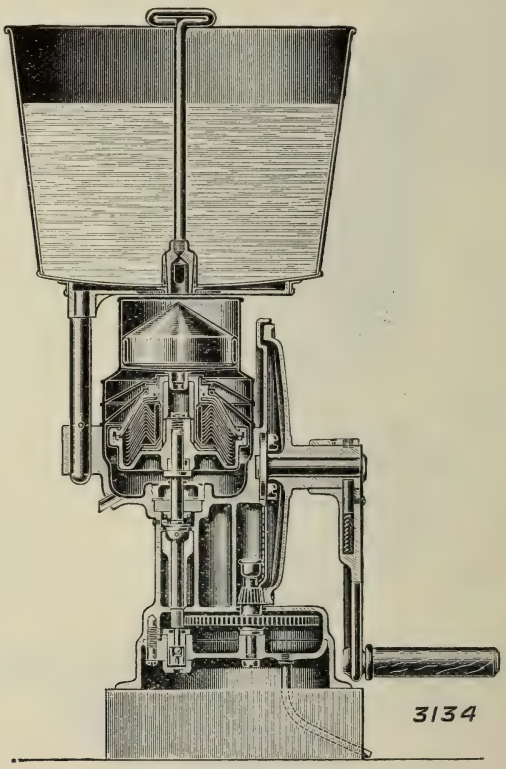

FIG. 8B.

"Princess" Separator—Cross-sectional View.

0·4 per cent. fat in favour of the separator as compared with the shallow pan. Thus in a 20-cow dairy (600 gallons per cow) an increased annual production of nearly 5 cwt. (542·2 lbs.) butter would be possible. The value of such butter is sufficient to pay for the cost of the machine in the first year of its use.

Management and Working of Separator.—Like all high speed power machines, the separator requires careful attention in its erection and in its manipulation. The iron framework stand on which the separator is ordinarily mounted must be bolted down to a perfectly solid and level foundation, preferably of stone or cement. Rigidity for the support of the machine is essential if vibration, which causes a loss of fat, is to be avoided. If the stand is not level the spindle carrying the bowl will be inclined to the vertical, and again vibration will follow.

All bearings, and particularly the top and bottom bearings of the spindle, should be kept well oiled. A good lubricating non-clogging oil is required. Occasionally the bearings should be flushed out with paraffin, petrol, or benzol and re-oiled.

In assembling parts of the bowl it is well to see that the rubber ring, by which a water-tight joint between the upper and lower portions of the bowl is secured, is resting evenly and unbroken in its groove. Unless a perfect joint is secured here the milk in the bowl will escape by this way during the process of separation.

The cream or skim screw should be so adjusted that about one-seventh of the milk will be returned as cream. With average milk such cream will contain about 30 per cent. fat, and will yield $3\frac{1}{4}$-$3\frac{1}{2}$ lbs. butter per gallon. A thinner cream is not desired, as it results in too great a loss of fat in the butter-milk. A thicker cream is apt to lump when churned.

The machine should be started slowly, the number of revolutions of the crank increasing gradually until the full speed has been attained. No milk ought to be admitted into the bowl until this point has been reached.

Throughout the process of separation an even and uniform speed should be maintained. Uneven driving entails an increased loss of fat in the separated milk. Most hand-power machines skim cleanest when the handle makes 60 revolutions per minute.

Just before the machine is started on a run it should be flushed out with hot water. This warms up the metal of the bowl and delivery spouts and prevents the cream from adher-

ing to these parts during cold weather; it also enables the operator to determine whether or not a tight joint between the upper and lower portions of the bowl has been secured. If the hood is not resting evenly on the rubber ring when the lock-nut has been screwed home the water will escape by the joint.

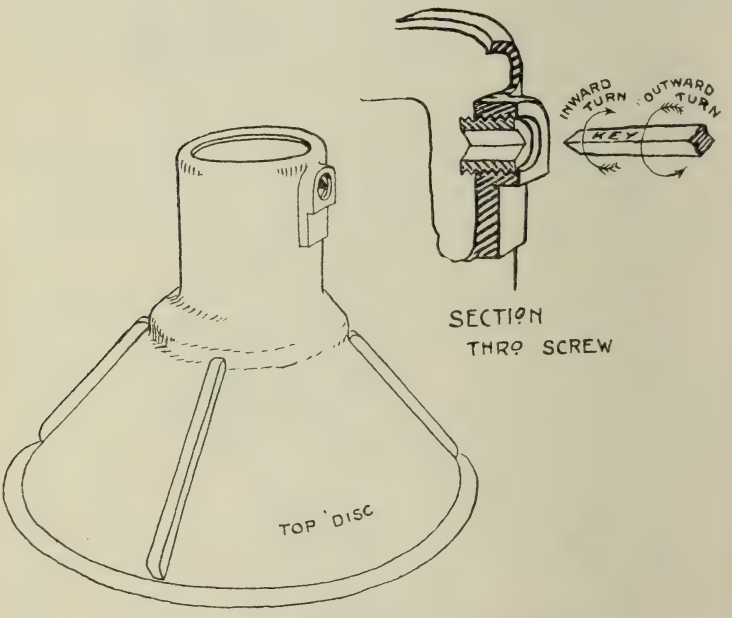

Fig. 8c.
Top Disc of "Alpha Laval" Separator, showing cream screw and its adjustment.

The temperature and condition of the milk are important points in separation. Within limits, the higher the temperature the less viscous the milk and the cleaner is the skimming. Between 130° and 160° F. the loss of fat (*ceteris paribus*) is at a minimum; at temperatures below 90° F. the increasing viscosity of the milk interferes with the efficiency of the process, and hence if the milk has become cold it should be heated up to blood heat before separation. As a general rule, milk should not be separated below 80° F. The milk should also be clean and well strained. Though it is true the separator removes dirt from the milk, yet if much sediment be present in the milk the deposit which quickly

gathers on the inner wall of the bowl retards the process of separation and ultimately clogs the machine altogether. For the same reason stringy milk, sour milk, or milk containing colostrum is unsuitable for mechanical separation.

After each run some of the separated milk is again passed through the machine to remove any cream still remaining in the bowl and delivery spout.

No attempt should be made to brake the bowl so as to stop it when dismantling the machine, as this will ultimately throw it out of balance. The bowl should be allowed to run down of its own accord; with some machines ten minutes or more may elapse before the bowl comes to rest. The separator is then taken apart and the pieces washed in lukewarm water containing some cleansing agent (*e.g.*, soap or soda), and scalded in boiling water for one minute. This scalding sterilises the parts, and, by ensuring quick drying, prevents rusting.

The separated milk should be occasionally tested for fat. If a high reading is consistently obtained, and the usual causes of loss of fat are eliminated (*e.g.*, vibration produced by the separator being mounted on an uneven or unstable foundation, bowl out of balance, loose or dirty bearings, uneven driving, unsuitable temperature, &c.), then the cream emerging from the cream screw is being partly diverted into the skim-milk chamber. This is caused by the bowl being too low set in the frame. By unscrewing the lock-nut at the lower end of the spindle and slightly raising the lower bearing so as to bring the cream screw above the floor of the cream chamber the bowl may be brought into proper adjustment and the loss of fat from the foregoing cause obviated.

The sticky mass which will be found adhering to the inner wall of the separator bowl after a run is known as the "separator slime." It consists principally of foreign matter originally present in the milk, together with a small amount of casein and certain milk salts. The nature and amount of the slime is a fair index of the purity of the milk. Very clean milk will give an almost white slime. Average milk usually gives a grey deposit and will yield about 1 part separator slime for every 5,000 parts milk separated; dirty milk, 3 to 4

times this amount. When the deposit is reddish in colour there is evidence here of abnormal milk (" bloody " milk). Such milk is always suspicious, and an inspection of the milk of each cow should be made at the next milking in order to determine the origin of the trouble.

Pasteurising the Cream.

The cream obtained by any of the foregoing methods is next pasteurised. The process of pasteurisation—named after the celebrated French scientist, Pasteur—consists in heating a liquid to a temperature sufficiently high to kill off the active forms of germ life (vegetative forms) present therein, and in immediately cooling it back to a low temperature. (This process may be applied to wine, water, and liquid foods generally, as well as to milk and cream.) Many of the organisms found in raw milk or cream, if allowed to develop unchecked, would produce bad flavours in the butter and detract from its keeping qualities. To destroy these organisms and to purify the cream before it is made into butter is the primary object of pasteurisation. Butter made from pasteurised cream has a better flavour, and keeps longer than butter made from raw cream. By its adoption produce of a very uniform quality may be made. Perhaps the greatest advantages of pasteurisation lies in the fact that it kills off disease-producing germs which frequently occur in milk and cream (*e.g.*, tuberculosis). It has been proved that butter can carry the germs of tuberculosis for three months.

Methods of Pasteurisation.—The maximum temperature to which the milk or cream is heated during pasteurisation is a matter of first importance. When high pasteurising temperatures are used (160°-180°F.), the duration of the heating process is short—the cream as a rule being only momentarily exposed to the latter temperature. This is called the *Flash Method.* When low pasteurising temperatures are employed (140°-155°F.), the time of heating must be longer in order to effect the same reduction in organisms. This is known as the *Holding Method.* At a pasteurising temperature of 140°F., the minimum exposure should be for 30 minutes. For every

degree above 140°F. the time of heating may be shortened by one minute, but in no case under the Holding Method should the exposure be less than ten minutes. The Holding Method is better adapted for milk or cream intended for sale; the Flash Method is favoured where the pasteurising of cream for butter-making on a large scale is practised. In milk depots and in butter factories special machines, called pasteurisers, are employed, but on the farm the pasteurising may be done in any suitable container which is capable of being quickly heated and cooled. For quantities above ten gallons a small

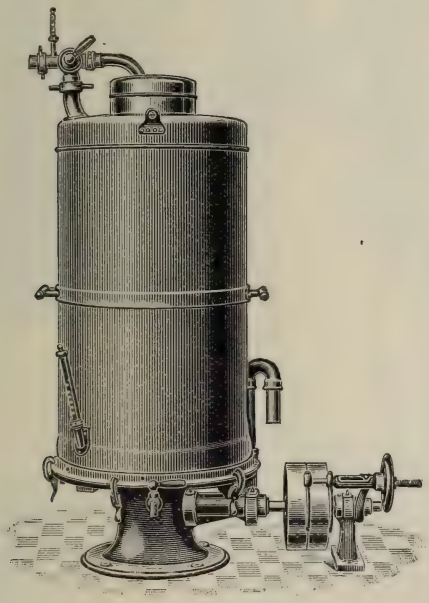

Fig. 9.
Regenerative Pasteuriser.

double-jacketed vat is most convenient, the heating and cooling being effected by successively admitting hot water (or steam) and cold water into the jacket. Quantities between two and ten gallons may be pasteurised in a tinned steel drum by simply immersing the latter in boiling water and constantly stirring the cream until the desired temperature has been reached, and then cooling down in circulating cold

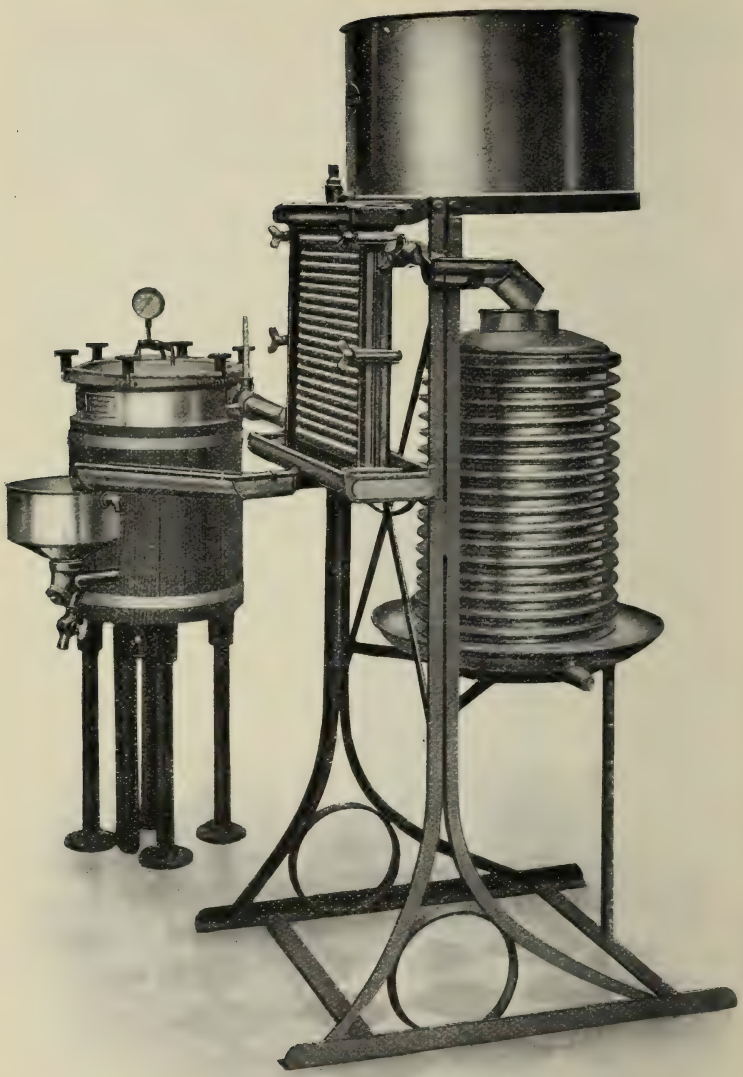

FIG. 10.

COMPLETE PASTEURIZING PLANT.

The milk is poured into the Milk-receiving Tank above. It then passes a Filter and over the Regenerative Heater, and from there into the Pasteurizer. From the Pasteurizer it returns and passes through the Regenerative Heater from below upwards, and finally over the Milk Cooler. Thus the cold milk, flowing over the surface of the Regenerative Heater, is partially heated by the hot milk ascending through the Heater from the Pasteurizer, and in this way an economy of steam and cooling water is effected.

water. An enamelled pail may be used for quantities of less than two gallons.

For farm butter-making a convenient and effective pasteurising temperature is 150°F. for twenty minutes, especially when fresh butter, intended for immediate sale, is produced. At this pasteurising temperature, no cooked flavour is obserable in the newly made butter. But when powdered or salt butter is made higher pasteurising temperatures may be adopted, because of the improved keeping quality imparted to the butter. The cream may either be heated to 160°F. for ten minutes or up to 180°F. with immediate cooling. The ultimate effect is about the same so far as the destruction of bacteria is concerned, but the higher temperature requires considerably more cooling water to subsequently disperse the heat. In Denmark pasteurisation to a temperature of 80°C. (176°F.) is compulsory. At this temperature—and, indeed, at all temperatures over 160°F.—a distinctly cooked flavour is imparted to the cream and to the fresh butter made from it. In the case of the butter, however, the cooked flavour disappears in the course of three or four days.

During the heating process the cream should be continuously agitated to distribute the heat, and to render the pasteurising temperature more effective. It has been shown that, when the milk is heated, a protective film derived from the milk substances forms round the bacteria, thereby delaying their complete destruction. Thorough agitation is required to disperse this film.

After being held at the pasteurising temperature for the desired length of time the cream is cooled down, usually to 70° F., in preparation for the next step—ripening. Quick cooling should be aimed at.

sweet and pure; have the cream well covered up.

On completion of pasteurisation every effort should be made to protect the cream from all external sources of contamination. The whole advantage of the process will have been thrown away if the cream, which should now be practically germ free, is exposed to the gross contamination of dirty utensils, an impure atmosphere, or flies. See that all appliances and vessels with which the cream is brought into contact are thoroughly sterilised; keep the air of the dairy

Ripening the Cream.

Preparatory to churning the pasteurised cream is subjected to a preliminary souring process called "loppering" or "ripening." The chief objects of ripening cream are (*a*) to produce the aroma and flavour which is always associated with good butter; (*b*) to increase the churnability of the fat; (*c*) to improve the keeping qualities of the butter. Butter made from unripened cream lacks the distinctive flavour of that made from well-soured cream. Obviously, then, flavour is closely associated with the acidity developed in the cream. When the cream is well ripened it is easier to churn than stale cream, and there is a smaller loss of fat in the butter-milk (0·2 per cent. as against 0·3 per cent.). Butter made from ripened cream as a rule keeps better, because the acid developed during ripening exercises a protective action and tends to suppress those germs which produce bad flavours and detract from the keeping qualities of the butter.

Method of Ripening.—Cream or milk for butter-making is almost universally ripened by means of starters. Now a starter is simply a vigorous growth in sterilised milk of cer-

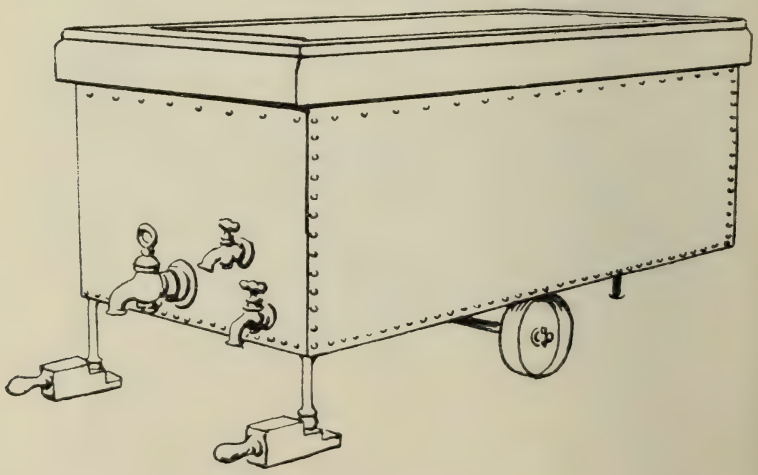

Fig. 11.

Double Jacketed Vat for ripening cream.

tain germs which produce lactic acid only. To the uninitiated a starter appears to be, and indeed is, pure sour

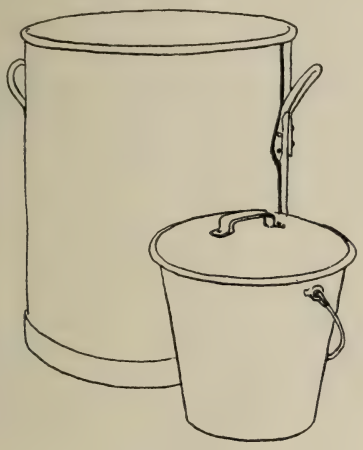

FIG. 12.
Cream Ripening Drum and Pail.

milk. Milk allowed to sour naturally, differs from starter in this important respect that it contains, besides the ordinary lactic acid germs, bacteria which mostly produce bitterness and bad flavours. In other words, ordinary sour milk is an impure or mixed culture, whereas the distinguishing feature of starter is that it is a pure culture, containing a definite type of lactic acid organism, technically known as *Streptococcus lacticus*.

The purity and vigour of the starter are of paramount importance. It cannot be too strongly impressed on the butter-maker that, when pure milk or cream is used, it is the starter more than any other factor which determines the flavour and keeping qualities of the butter, and without flavour butter is nothing.

Starter may be prepared *ab initio* from the dry powder form which is sold in hermetically sealed bottles, but as specialised methods are required to obtain pure and vigorous cultures from this source, the butter-maker is advised to procure a "ready-made" starter from a dairy institute of some

repute. In propagating (or carrying on) this pure culture from day to day every effort must be made to keep it vigorous and free from sources of contamination. As soon as a new culture is received it should be inoculated into pasteurised or, preferably, into sterilised milk at a temperature of 70°-80°F. To be of any service for starter-making, pasteurising must be well done, and within recent years the process of double pasteurisation has found favour. This method consists in heating the separated milk to 190° F., cooling it down to 70° F., and allowing it to stand at this temperature for 2-3

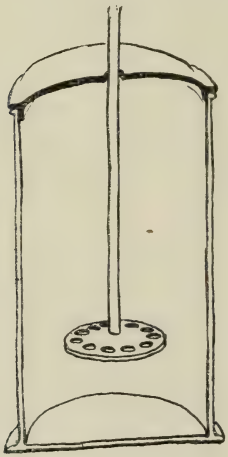

FIG. 13.

Pasteurising Can.

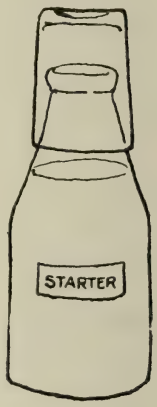

FIG. 14

hours; again the same milk is heated to 190° F. and cooled back to that temperature at which the starter is inoculated—70°-80° F. A special pasteurising can is usually employed for doing this work.

In propagating the starter, which should be done daily, about 5 per cent. of the mother-culture is inoculated into the pasteurised milk—*i.e.*, about two teacupfuls per gallon.

An enamelled pail or can is the most convenient receptacle in which to keep starter, because its smooth surface makes it easily cleaned and sterilised. The pail may with advan-

tage be provided with an easy-fitting overlapping lid. This is a better cover than muslin, &c. On a smaller scale a milk bottle may be employed, the mouth being protected either by a cotton-wool plug or by an inverted tumbler.

After inoculation the starter should be kept at a temperature of 60°-70° F. until it thickens. With a vigorous culture coagulation takes place in about 12 hours. Starter should not be allowed to become over-ripe; excess of acidity greatly weakens its activity and renders it more liable to contamination by injurious yeasts and moulds. When ready for use it ought to be in a softly coagulated condition. If this stage is reached in advance of the time it is required, injury from over-acidity may be prevented either by adding some freshly pasteurised milk to the starter or by cooling it down to below 50° F. The starter is always kept well covered up and away from the direct rays of the sun.

Whenever the starter becomes thin and less vigorous or loses its pleasant clean acid taste, or becomes in any way bitter, it should be immediately rejected. Generally a starter, under average farm conditions, lasts about a month; at the end of this time it should be renewed.

Before the introduction of pure culture starters many progressive dairymen were wont to add some of the butter-milk from the previous churning to the new milk or cream in order to assist the souring process. Butter-milk starters are still employed to a limited extent, especially by those who make whole-milk butter. So long as the butter-milk possesses a mild, clean, acid taste, quite free from staleness or bitterness, it may give quite good results in butter-making. As soon, however, as it goes off, it is quite useless, and its continuance is certain to perpetuate a bad flavour in the produce.

The quantity of starter required to ripen cream in 12-20 hours is usually from 5 to 10 per cent., *i.e.*, from $\frac{1}{2}$-pint to 1 pint starter per gallon of cream. The starter should be added to the ripening vessel (earthenware crock, enamelled pail, steel drum, or double-jacketed vat) before the pasteurised cream is run in, as this ensures a better distribution of the starter. The contents of the crock or vat are then thoroughly stirred and left to ripen or "lopper."

The most suitable temperature for ripening cream is from 65°-75° F., with a mean of 70° F. When only small quantities of cream are being handled the temperature of the cream in the ripening crock is apt to fall quickly, especially if the surrounding air is cold. In these circumstances the starter may be added at a cream temperature of 80°-90° F. During the early stages of the ripening process the cream should be agitated from time to time. By preventing creaming, agitation ensures more even ripening. Some authorities also claim that an occasional stirring of the cream throughout the ripening period improves the flavour of the butter.

In normal circumstances ripening will be complete in 8 to 12 hours. Slow ripening is due to a weak starter or too low a temperature of the cream. Under such conditions bitterness is almost certain to intervene. A high ripening temperature means a rapid development of acid, but if the temperature be too high—*i.e.*, above 90° F. throughout—gassiness wil develop in the cream, a condition which is usually attended with a somewhat disagreeable flavour.

Over-ripening the cream should be avoided, as butter made from such cream does not keep well. As soon, then, as the proper degree of acidity has been developed, the cream should be immediately cooled down.

Ripening Gathered Cream.—When only a small quantity of cream is available each day it is the custom to gather the cream for several days in succession until sufficient has been got together to make a churning. In these circumstances one of two methods may be followed :—(1) The cream may be held over at a low temperature until the desired quantity has been reached, and then ripened in one batch. Butter made by this method very frequently develops a bitter taste. (2) The first lot of cream, after pasteurisation, is added to the clean crock containing a small quantity of starter : each succeeding day's cream is added to this and thoroughly stirred. No fresh cream is added 12 hours before churning. This system gives better results than the previous, but the butter has not such good keeping properties as that made by the standard method.

Hardening the Cream.

On the completion of the ripening process the cream is prepared for churning. This operation implies more than the immediate adjustment of the cream to the desired churning temperature. It means that the fat globules in the cream are brought into the best physical condition for churning. At the ripening temperature (70° F.) the fat globules are in a semi-liquid condition; at temperatures under 50° F. the fat globules become much harder and firmer, and if the cream could be churned after being held at this temperature the resultant butter would be very hard and firm. But, as fat is a bad conductor of heat, it takes some considerable time for the lowered temperature to exercise its effect in changing the fat from the semi-liquid to the semi-solid condition which is desired at churning-time. Usually a period of three hours is required to harden the fat in this way.

As soon, then, as ripening is complete, and at least three hours before churning, the temperature of the cream should be reduced 5 or 6 degrees below the churning temperature—that is, the cream should be chilled to 50° F. If this is done the cream may subsequently be churned at a higher temperature than usual. The hardening of the cream is an important step in early summer, when the butter is naturally soft and a good texture difficult to secure.

Churning.

Cream ready for churning should have a smooth, velvety appearance, and a short brittle "texture." When stirred up it should drop from the wooden rod like molten metal. Most important, it should have a clean, acid taste and smell, and be free from any suggestion of staleness, bitterness, or over-acidity. The acidity desired in cream at churning time is ·5 per cent. to ·6 per cent.; if the cream contains much more acid the butter does not usually keep so well, probably because a highly-acid cream is more attractive to yeasts and moulds.

The cream is now brought to the proper churning temperature. This is usually done by thinning water, the tem-

perature of which is regulated accordingly. The maximum quantity of thinning water it is desirable to add is 10 per cent., but less will usually suffice. As a rule, it is better to adjust the temperature of the cream by heating or cooling the containing vessel than to add large quantities of thinning water. (After the temperature has been obtained by the latter method, thinning water, if necessary, can be added at the temperature of churning.) If the cream is sufficiently fluid at churning time no thinning water is needed. Thinning water *must* be pure.

Fig. 15.

"End over end" Churn, with lever fastenings.

An end-over-end churn, made of well-seasoned oak and provided with a lid secured by a lever, is the best type for churning quantities up to ten gallons. Power churns of the modern type, in the form of horizontal cylinders with revolving paddles or beaters, are now used on up-to-date butter-making farms. Large-sized end-over-end patterns are also frequently employed. The old box-pattern is being discarded; it is neither sanitary nor economic.

Prior to the introduction of the cream the churn is thoroughly prepared for use. It is scrubbed with clean luke-warm or cold water, scoured with salt, and left with water at

the churning temperature what time the cream is being got ready. New churns before being used should be steeped for some days with changes of clean cold water containing a little slaked lime or salt.

The mean temperature of churning (to which the cream is adjusted) is 56° F., but it varies from 54° F., in late spring and early summer, to 64° F. in winter. The rule is to churn at the lowest temperature which will give butter in a reasonable time—*i.e.*, thirty minutes. A high temperature of churning results in a rapid formation of butter, but in such a case a good grain is seldom got, lumps are difficult to avoid,

Fig. 16.
"End over end" Power-driven Churn.

and there is a large loss of fat in the butter-milk. A low cream temperature means a prolonged churning, and a small, hard grain. Too low a temperature will altogether prevent the formation of butter. Cream which is over-acid requires to be churned at a lower, and stale or aged cream, with little acid, at a higher, temperature than normal. When the cows are getting much cottonseed or earthnut cake a higher churning temperature is desirable. Sweet cream must be churned at not more than 54°F., while whole milk is churned at temperatures varying from 60° to 65° F.

The water having been run off, the cream is strained into the churn through a coarse straining cloth. Curdy particles, the presence of which in the butter would cause white specks, are thereby removed. A rubber squeegee applied to the straining cloth will remove any adhering cream.

Colour, if required, is now added. The colouring matter commonly employed is annatto—an extract of a sub-tropical plant, *Bixa orellana*, dissolved in sesame, cottonseed, or "oleo" oil. When purchasing annatto the dairyman should always state the purpose for which it is required; butter annatto is quite a different preparation from cheese annatto, and the latter cannot be substituted for the former in butter-making. The quantity of colour required in winter, when the fat is dead white, is on an average 3 ounces per 100 gallons of cream, or a teaspoonful to every 3 gallons. This amount will give the pale straw shade which is the normal colour of the fat when the cows are at pasture in midsummer. As soon as this colour appears naturally no annatto need be added. In south-west Scotland this occurs in early June. The colour is added undiluted to the cream in the churn, and churning then begins.

Churning starts slowly at first, the release valve (or "ventilator") being pressed at every two or three turns until no more "gas" escapes. (This gas is mainly water vapour). The full working speed, which, generally speaking, is 40-50 revolutions per minute, is then got up. A much higher speed than this would defeat the whole aim in churning; the cream, instead of falling from the top to the bottom of the churn at each revolution, and being thereby subjected to the necessary concussion, would simply rotate with the churn. As it is this concussion to which the cream is subjected during churning that causes the formation of butter granules, the importance of a regulated speed will be readily understood.

The time occupied in churning is on an average about 30 minutes, but it varies greatly. The factor which influences the time of churning more than any other is the temperature. A low temperature greatly delays the

formation of the butter, and is one of the commonest causes of prolonged churning ("sleepy cream"); a high churning temperature makes the butter come quickly, but it ruins the grain and texture of the butter. Again, when the churn is more than half full the butter is slow in appearing, because the force of concussion is so greatly diminished. For good results the churn should not be more than one-third full. A thick cream, well ripened, churns quicker than a thin cream. A cream containing 25-30 per cent. fat is just about the right consistency for butter-making. A cream of 40 per cent. is too thick for hand-churning, though a cream of this thickness is often employed in colonial factories. A cream with 12-15 per cent. fat is too thin, and takes too long to churn; the thinner the cream, the larger the total loss of fat in the butter-milk. The food of the cow and the season of the year also influence the time occupied in churning. Cows on pasture in early summer give milk which is easily churned, whereas the milk of cows on winter feeding is slow in giving butter. Certain concentrated foods, when fed in quantities above 2-3 lbs. per head, such as cottonseed, earthnut and palm-nut cakes, delay the churning; others, again, like bran, oats, and linseed, tend to speed it up. The method by which the cream is separated has some effect on the churning; as a rule separator cream churns a little quicker than shallow-pan cream, which in turn churns quicker than cream obtained by the deep-setting system.

At the beginning of the lactation the fat globules in the milk are larger than at any other period, and hence the milk of newly-calved cows is easily churned. On the other hand, the fat globules towards the end of the lactation are small, and on this account the milk of stripper cows not only takes longer to churn but the loss of fat in the butter-milk is higher than usual.

The nature of the starter and the manner in which the cream has been ripened influence very materially the time of churning. A pure-culture vigorous starter facilitates churning, whereas unpasteurised cream ripened naturally is often long in giving butter. The presence of certain kinds of organisms in the cream (capsule forming and stringy milk bacteria) render churning practically impossible.

Adding the Breaking Water.

Churning is continued uninterruptedly until the cream breaks. This stage is indicated by the observation glass (or "window") becoming clear and by the "splash" of the cream in the churn. When this point is reached the churn should be stopped and the breaking water added. During churning the temperature of the cream rises 2 or 3 degrees. (This is due to the fact that the mechanical energy of rotation has been converted into heat). To correct this rise in temperature and to bring the churn contents to the original churning temperature is the main object of adding the breaking water. By so doing a better grain and texture is possible, especially in summer-time, when the fat is naturally soft. There is also less danger of lumping during the completion of the churning process. In the winter-time or in cold weather the rise in temperature during churning is not observed, simply because the heat generated has been lost to the surrounding atmosphere by radiation.

The quantity of breaking water added should not, as a rule, exceed a quarter of the amount of cream in the churn; less will usually suffice, especially if its temperature be low enough. If the rise in temperature during churning is 2° F., the temperature of the breaking water should be 48° F. (25 per cent. water being added).

The breaking water is generally added in one lot when the butter is in the distinctly granular form, but if there are indications of the butter coming quick (as often happens in June and July), part of it may be added in advance just as soon as the mealy stage (the nuclear condition of the grain) is observed. The butter-maker, however, should avoid adding the breaking water too soon in cold weather or in circumstances when the cream is naturally difficult to churn.

Rounding off the Grain.

After the addition of the breaking water churning is continued slowly until the grain has been fully formed and rounded off. This is the critical stage in churning, for it takes but little concussion, once the grain is fully formed, for

it to pass into lumps. The grain, when finally formed, should be even and about the size of sago or wheat grains. While grain is not everything in butter-making, yet a really good grain is worth striving for. With a good grain the butter is more easily washed and worked and more uniformly salted, and these are considerations of the utmost importance in butter-making.

Washing the Butter.

With the completion of churning the butter-granules adhering to the inner aspect of the lid and sides of the churn are washed down and the butter-milk run off. The washing water should be ready to hand before the butter-milk is run off. A fine hair strainer, which may be covered with muslin, is used to intercept any butter grains in the butter-milk. If the churning has been well done the amount of fat in the undiluted butter-milk will not exceed 0·3 per cent.

The butter in the churn is then washed with pure cold water. This washing water should be a few degrees below the original churning temperature; generally the coldest water obtainable on the farm is used for this purpose. The amount of water required is approximately equal to the original churn contents. The actual quantity, however, is not an important matter so long as it fulfils the main object —to wash away completely the butter-milk. Two washings are quite sufficient, one in water and one in brine. *The first washing should be as thorough as possible.* After the butter-milk has been run off, the wash-water is immediately added and the churn given six slow and six fast turns. The lid and sides of the churn are again washed down and the water, which is now milky in appearance, run off through the sieve.

The second washing is made with a 10 per cent. brine solution. This brine is prepared by dissolving ½ to 1 lb. good dairy salt per gallon of water and filtering through fine muslin. The temperature of the brine is adjusted to 46° F. by the use of ice if necessary. Enough brine water is used to float the butter. Ten to fifteen minutes are allowed for brining. If

the brine be strong enough, and the steep continued for thirty minutes, the butter may be salted by this method.

The objects of brining are to harden the grain and to bring up the flavour of fresh butter. The only objection to brining is its expense—approximately $\frac{1}{3}$d. per lb. of butter made.

Working the Butter.

After brining is complete the granular butter is removed from the churn by means of a perforated scoop, placed on an enamelled plate covered with muslin, and taken to the butter-worker, which has been prepared in advance for use. At the same time as the churn is being got ready the worker should receive attention and the same thorough degree of preparation.

The bed of the worker and the wooden roller are washed with tepid water, scoured with salt, scalded with boiling

Fig. 16A.
Butter-Worker.

water, and flushed with cold water. The worker is filled with cold water and left standing until the butter has been brined. A muslin cloth whose free ends dip into the water covers the roller and keeps it damp during this period.

Unless the worker is carefully scalded and prepared in this way the butter during working will stick to the wood and become greased. It should also be noted that the worker is a frequent source of contamination, and bad keeping properties in butter otherwise carefully manipulated are to be attributed to this cause.

Having run off the water, the operator spreads out the butter evenly on the bed of the worker (taking care not to

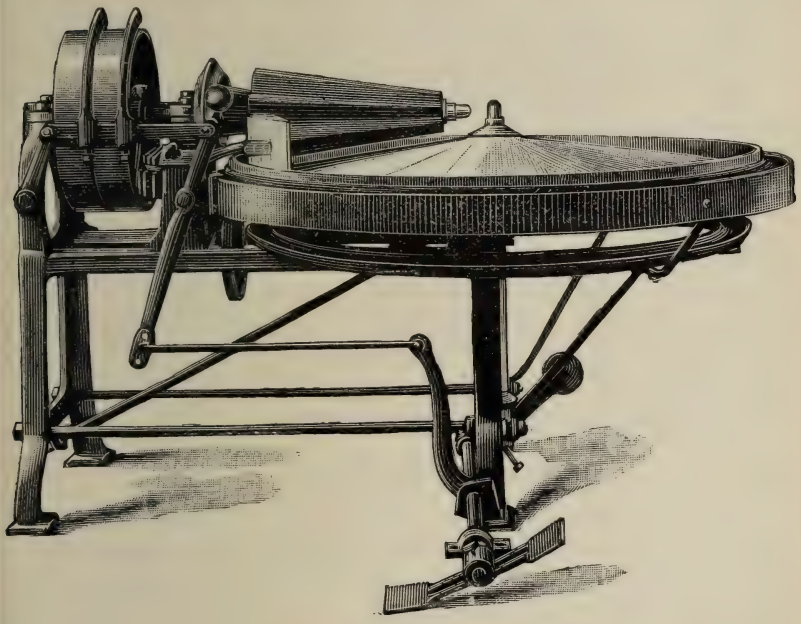

Fig. 16B.
Power Butter-Worker.

overload it) and passes the roller evenly over the mass. The speed of advance and the rate of revolution of the roller should synchronise; this will ensure an even pressure throughout, and greasing through friction will be avoided. After being rolled out in this way (unless when salted) the butter is immediately brought together again (using the Scotch hands for the purpose) and the process repeated until the butter is dry enough. Usually it requires 5 to 7 turns of the roller to work the butter completely. To determine when the butter

is dry enough a portion of the worked mass (about 1 lb.) is compacted into a block with the Scotch hands. The block is cut across and the section with the smooth surface laterally compressed between the wooden hands. The moisture which exudes should be small in amount and finely divided (like dew). If large globules of water emerge the butter contains too much moisture and requires further working.

In the warm weather of early summer the natural softness of the butter fat and the high atmospheric temperature combine to make effective working of the butter a difficult matter. With each passing of the roller the butter becomes softer and softer; comparatively little water is forced out, and the butter loses its texture and becomes greased. In such circumstances the butter, after the first or second turn on the worker, should be wrapped in a clean wet muslin cloth and laid aside on a cold (stone) slab for two or three hours. At the end of this time the butter will be sufficiently firm to allow of the working being completed without injury to the texture. If the butter is to be sold or consumed fresh within a week the operator proceeds to make it up forthwith, but if it is desired to prolong its keeping qualities beyond ten days the butter is powdered or salted before being bulked.

Salting the Butter.

There are two methods of salting—(*a*) dry salting, (*b*) salting in the brine. When the first method is adopted the butter, after the first turn of the roller, is sprinkled evenly with half the required quantity of salt and then brought together. The roller is passed over the butter again and the remainder of the salt applied. Another working is given to incorporate this salt and the butter set aside for 30 minutes, or until the salt dissolves. The working is then completed.

The amount of dry salt applied regulates the degree of saltness in the finished product. For powdered butter $\frac{1}{4}$-oz. per lb., for medium-salted butter $\frac{1}{2}$-oz. per lb., and for fully-salted butter $\frac{3}{4}$-oz. per lb. ($4\frac{1}{2}$ per cent.), are the quantities indicated. When more than 1 oz. per lb. is used the butter becomes gritty from the presence of undissolved salt.

A good dairy salt should be pure white in colour, sharp in the grain, and completely soluble. Bad salt is a frequent source of contamination, and occasionally of mottling, in butter. A simple test for the purity of salt consists in dissolving a handful in a half-pint of water. There should be no sediment or scum, and the solution should be quite clear.

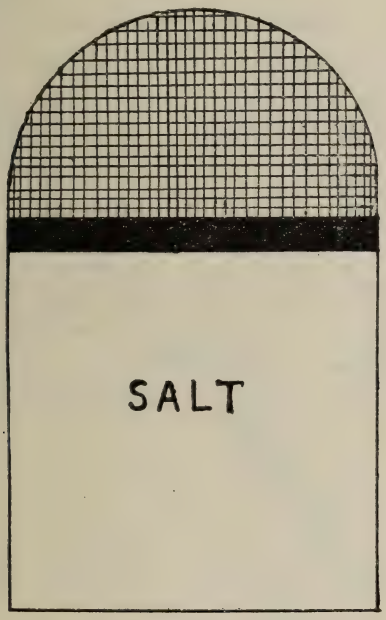

Fig. 17.
Special Salt Dredger.

Salting in the brine has three great advantages :—(1) There is no danger of mottling or streakiness; (2) it is scarcely possible to oversalt the butter by this method; (3) the working is completed at one operation. On the other hand, brine salting is much more expensive than dry salting. To obtain successful results from brining a good even-sized grain is necessary; butter which is lumpy is quite unsuitable. The brine solution is made by dissolving $1\frac{1}{2}$ lbs. salt per gallon of water (15 per cent. solution) and filtering through a three-ply cheese cloth, or preferably through a cotton-wool filter. The duration of the steep is 30 minutes. If the brine solu-

tion be pasteurised and refiltered it may be used over again, but, generally speaking, it is not worth while doing so.

After brining the butter is worked in the ordinary way. Butter which has been brine salted is usually firmer and more easily manipulated on the worker, especially in those seasons when the fat is naturally soft.

Making up the Butter.

Fresh and powdered butter made on the farm is put up in special shapes and retailed in half-pound and pound lots.

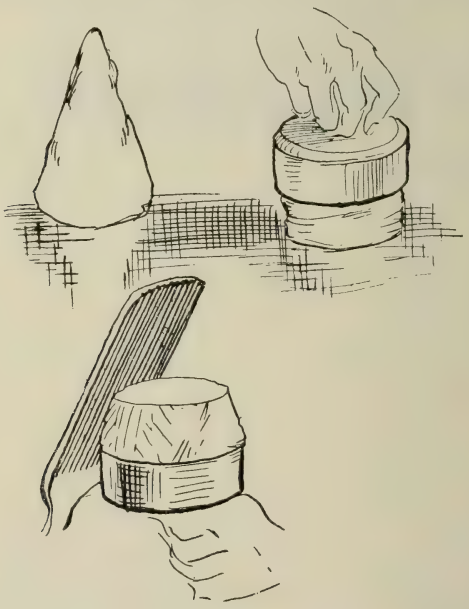

FIG. 18.
Making a Butter "Print."

Plain rolls and prints are popular in most districts, but blocks with special design are neater, though more difficult to make up. In weighing out the butter a due allowance should be made for loss of moisture on subsequent manipulation.

To make up a roll, the butter, after being weighed out, is compacted by the Scotch hands into an oblong block with

square ends. The longitudinal edges are slightly compressed and the rolling board passed over it. A skilled operator can make an almost perfect cylinder with a single sweep of the board. Novices are very apt to grease the butter when making it up into rolls.

Prints derive their design from a wooden die on which the butter is impressed. Prints are usually made up in quarter or in half-pound sizes. The butter is rapidly made into a plain squat block with the Scotch hands and set on its end

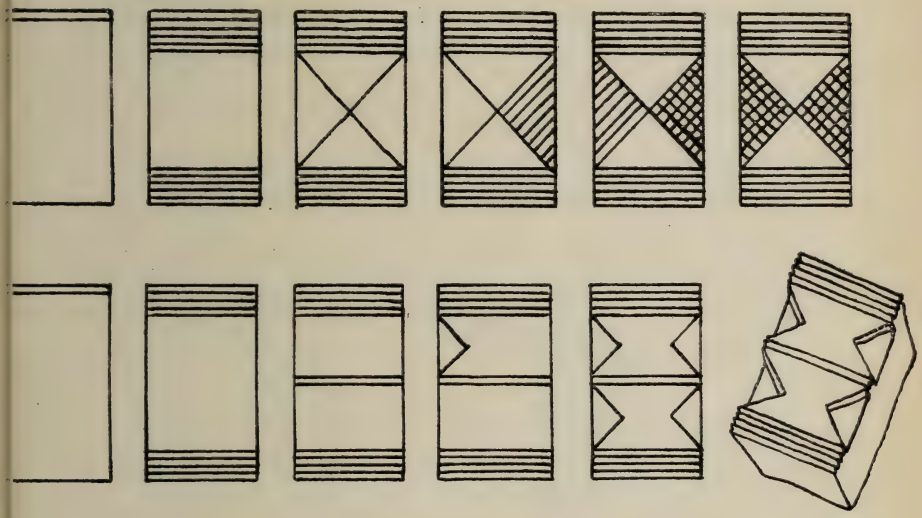

FIG. 19.

How designs are made.

on the butter-board. With the smooth faces of the wooden hands the square column is converted into a cone, and the print brought down its apex, compressing the cone so that the butter takes a sharp impression of the engraved surface. In doing this it is important to see that the face of the printing die is kept parallel to the board and that the compression is continued until the whole surface of the print is covered by the butter mass. (At this point the die surface will be about one inch distant from the board on which the butter is compressed.) The butter, still adhering to the die, is eased

off the butter-board and the lateral surface angled by gentle pats with the Scotch hands. A well-finished print should show the design of the die perfectly; the marginal edge should be sharp, and not ragged or irregular. Good, firm butter is required for printing; it is very difficult to print butter which is soft and watery in the texture.

Blocks are made up entirely with the Scotch hands, and, with care, very neat and attractive designs may be made. The measurements of a well-made-up block are 4 inches long, $1\frac{3}{4}$ inches broad, and 2 inches high. The accompanying illustrations show how two of the commonest designs may be impressed on a block of butter by the aid of a printing hand only.

Use of Ice on the Farm.

In warm summer weather, the employment of ice in the manufacture of butter may be necessary if the coldest water

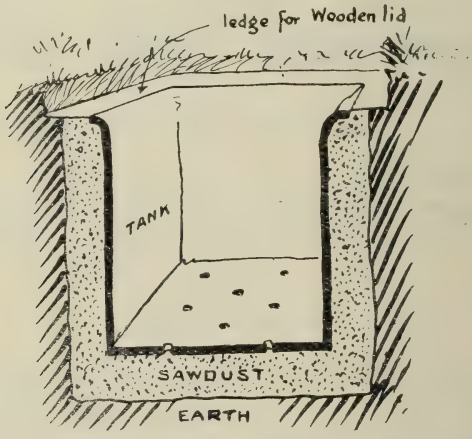

Fig. 20.
Ice Pit.

available on the farm is too high for washing and brining the butter, *i.e.*, is above 54° F. Ice, however, is apt to become a very expensive item, unless due care is taken to prevent unnecessary loss and waste. To conserve ice properly, it should be stored in a well-made ice chest which is provided

with a close-fitting lid, and kept in the coolest part of the dairy. Again, it may be stored in an ice pit. The latter is made by excavating a pit in the ground in a shady spot outside the dairy altogether. The bottom of the pit is covered with shavings, and a disused tank, bin, or glazed trough set thereon. The space between the receptacle and the sides of the pit is packed with dry cork sawdust. The receptacle is provided with a lid or cover, and a grating placed over the mouth of the pit. This grating may be covered if necessary by wet matting or fibre. Ice protected in this way melts little even during hot weather. An ice pit offers the further advantage that the fresh butter in summer time may be considerably firmed up by placing the plates or trays containing it on the top of the ice block.

POTTED BUTTER.

Farm butter, which is so made that it may be kept or preserved for some considerable time before it is required for use, is spoken of as "potted butter." The name is probably derived from the fact that the butter is stored in earthenware crocks or "pots."

For the preparation of potted butter only the best quality of milk and cream should be used; second-grade milk or stale cream is quite unsuitable. The cream should be pasteurised to a temperature of 170° F. for ten minutes, and carefully ripened at 60°-65° F. with a good starter to a low degree of acidity—·25 per cent. to ·35 per cent. The cream should not be too sour; potted butter made from a highly acid cream has poor keeping properties. A relatively low churning temperature is employed. A good, even-sized grain is desirable, to facilitate the washing of the butter, which in the case of potted butter must be very thorough and complete. The rule is to wash until the water runs clear; this usually entails two washings in water and one in brine. Salt is added at the rate of $\frac{3}{4}$ oz. per lb., and after the salt has dissolved the butter mass is worked somewhat drier than usual. The butter is well packed into a clean glazed-earthenware crock, a butter beater being used

to consolidate the mass. The top is covered with a 2-inch layer of salt, and a sheet of parchment paper tied over the mouth of the crock. The essential thing in packing the butter is to exclude air, otherwise moulding and rancidity intervene.

Fig. 21.
Butter Packer

The butter should be stored in a cool, dry place.

Some makers add $\frac{1}{4}$ per cent. boric acid (1 oz. to 25 lbs.) to the butter on the worker, but this is not usually necessary if the butter has been well prepared.

WHOLE-MILK BUTTER.

Whole-milk butter is still made to a considerable extent on dairy farms in south-west Scotland. The thick butter-milk, for which an enhanced retail price is obtained, and the fine flavour of the butter when carefully made are reasons for its survival. As pasteurisation of the milk is scarcely practicable, extra care should be taken to produce a pure, high-grade milk, and strict attention to the minutest detail as

regards sanitary milking and the cleanliness of the dairy and of utensils must be observed.

Whole milk is usually ripened in drums of heavily tinned steel or in large oaken casks, capacity 50 gallons. The object of using wooden containers is to maintain the necessary temperature during loppering. The evening's milk may be set in deep plates, mixed with the warm morning milk, and adjusted to the required ripening temperature before being set in the oaken casks. The initial temperature at which the mixed milk is set to ripen will vary with the season: in winter, from 80°-90° F.; in spring and autumn, from 70°-80° F.; and in summer, from 60°-70° F.

The quantity of starter required is 5-10 per cent. for a ripening period of 24 hours, the larger quantity being used in winter. After the addition of the starter the milk is well stirred for five minutes, a plunger being employed for this purpose. Three hours later the cream which has risen to the surface is stirred down and the milk left untouched until ripening is completed. The partially coagulated milk should on no account be disturbed, otherwise the casein settles out, carrying with it some of the fat, which cannot be recovered by churning. As a consequence, each day's milk must be ripened in separate casks or drums.

When fully ripened the milk should appear as a solid homogeneous mass; there should be no separation of whey; the smell and taste should be pleasantly acid, without any suggestion of "sourness" or bitterness. The acidity at this stage is about ·8 per cent. The temperature will probably be several degrees below the churning point, but this lowered temperature will materially assist in hardening the grain, which in whole-milk butter tends to be softer than usual, especially in summer.

When ready for churning, the temperature having previously been adjusted, the loppered milk is added to the churn. Whole milk must be churned several degrees higher than ripened cream. The usual churning temperature is 60°-66° F., according to season. This point should receive careful attention, because if an attempt be made to churn whole milk at temperatures suitable for cream the churning would be

practically without effect so far as the formation of butter is concerned. The churning temperature is reached either by removing and heating part of the ripened milk or by standing the containing vessel in hot or cold water as required. When large volumes of milk are being handled, and the temperature is several degrees from the churning point, the latter procedure presents obvious difficulties if the milk is ripened in oaken casks. Again, the addition of any considerable quantity of thinning water would give a thin butter-milk, a circumstance which must be avoided if the butter-milk is intended for sale. It is better to adjust the temperature by means of pasteurised separated or skim milk.

A double-jacketed vat would be a more convenient ripening vessel to handle, but the high acidity of the ripened milk would tend to corrode the metal surfaces. This defect might be overcome by using silica-coated steel instead of tinned steel in the construction of the inner lining of the vat.

The time of churning of whole milk is from $1\frac{1}{4}$-$1\frac{1}{2}$ hours. (This is one of the great drawbacks to the churning of whole milk.) Relatively less breaking water is required than when cream is churned; 8 per cent. to 10 per cent. of the churn contents will be ample. Nothing is to be gained from the point of view of recovering the fat from the butter-milk by adding more than 10 per cent. water at this stage. The grain is invariably smaller than that obtained from ripened cream; it separates out from the thick butter-milk with difficulty, and there is always a considerable loss of fat in the butter-milk (amounting, as a rule, to 0·5 per cent.). After churning is complete, and before the butter-milk is run off, the churn contents should be left undisturbed for 10-15 minutes, so as to enable the smaller butter-grains to rise to the top.

The strainer through which the butter-milk is run requires to be of larger mesh than usual, otherwise the pores become quickly blocked up with curdy particles. Effective straining of the butter-milk is a slow process.

Whole-milk butter is more difficult to wash than the butter from ripened cream, and white specks in the finished product are of more frequent occurrence. Over-washing must be

avoided if the fine, full flavour of the whole-milk butter is to be retained.

The brining period should be longer than usual, *i.e.*, from twenty to thirty minutes, and the brine as cold as possible, because of the higher temperature of the fat due to the high churning temperature.

On account of the smallness of the grain the working demands careful attention, as greasing may very readily happen. Indeed, to secure a first-class texture is by no means easy of accomplishment.

Apart from minor difficulties, the three principal drawbacks to the manufacture of whole-milk butter are the bulk of milk to be handled, the length of the churning process, and the loss of fat in churning. Except when well made, its keeping properties are inferior to butter made from pasteurised cream, but the immediate flavour of the newly-made butter—when clean milk and a good starter are used—is of a high order. Whole-milk butter is purely a farm product, and is not made under factory conditions.

SWEET CREAM BUTTER.

Within recent years a considerable amount of sweet cream butter has been put on the market. It is mainly a factory product. Canned butter is of this type. The flavour is very mild and creamy—nearly that of the pure butter-fat—and to many people appears insipid; it lacks character. On the other hand, when well made it has good keeping properties.

The process of manufacture is simple. Fresh milk is separated and immediately pasteurised, preferably by the holding process. The pasteurising temperature now adopted is usually high—170° F. for ten minutes. The pasteurised cream is chilled to 45° F. and held at that for three hours before churning, so as to harden the fat. This step is absolutely essential in sweet cream butter-making if a large loss of fat in the butter-milk is to be avoided.

The churning temperature is several degrees lower than ripened cream—52°-54° F.; not any higher, otherwise a great loss of fat occurs in the butter-milk.

Churning is complete in 20-30 minutes. During churning the temperature rises two or three degrees. This must be corrected by the early addition of breaking water, otherwise lumping is very likely to occur.

Sweet cream butter should be well washed, and then brined for 20 minutes. A mild salting, 2½-3 per cent., is usually given.

In America what is termed sweet cream butter is made by churning up pasteurised cream with 20 per cent. starter. The flavour of such butter is intermediate between the ordinary and pure sweet cream product.

Judging Butter.

In comparing the relative merits of different samples of butter and passing judgment on them recourse is generally had to a scale of points. The following scale is widely used in shows and competitions in south-west Scotland :—

Flavour, ...	45
Texture, ...	25
Colour, ...	15
Appearance and finish, ...	15
	100

This scale awards too little to flavour and too much to colour. The flavour of good butter is its greatest attribute, and more than half the total points should be awarded to this quality. Again, the colour of butter is of minor importance; throughout the greater part of the year artificial colouring is used, and the shade can easily be modified to suit the market demands. It does not require much skill to colour butter. At the same time, a dead-white butter, or one which is too highly coloured, is not pleasing to the eye, and this will, unconsciously, weigh with most people when passing an opinion on the quality of any sample. "Appearance, colour, and finish" may well be considered together.

The following scale is better balanced :—

Flavour and aroma, ...	60
Body and texture, ...	25
Appearance, colour, and finish, ...	15
	100

The flavour should be pleasing, distinctive, and characteristic of good butter. The lactic acid "touch" developed by the ripening process should be retained as fully as possible, and should be unmistakably apparent to the palate. Over-washed butter has little real flavour, because the products of ripening which are really responsible for flavour have been mostly removed by the washing water. Butter-fat is more easily affected by the lactic acid fermentation of milk than are other animal or vegetable fats.

Aroma is closely associated with flavour, and is always made use of in judging butter. Aroma is due to certain volatile principles developed in the butter, and to appreciate it properly the freshly-cut surface should be immediately passed under the nose. Good butter has always a pleasant aroma—easy to detect, but difficult to describe. Some butters whose flavour is quite good have comparatively little aroma. Butter made from stall-fed cows has less aroma than grass or stubble butter.

Aroma cannot always be relied on in judging. Some times a butter with a poor, or even bad, flavour may have a good aroma; on the other hand, a bad aroma invariably indicates a bad flavour.

Body and texture are so closely related that many authorities consider them indistinguishable.

Body refers to the firmness and solidity of the butter. When a sample of butter is pressed between the fingers it should have the consistency of cold pork. Texture has reference to the closeness and compactness of the butter. A freshly-cut surface should be perfectly solid, without any holes; when such a surface is laterally compressed no large drops of water should appear; the exuding moisture should be fine and

evenly divided, and should be clear and not milky. If a block of the butter is cut nearly through with a smooth wooden "hand," and one half jerked apart from the other, the broken surfaces should show a metallic fracture—like broken steel.

Butter which has a defective texture or a weak body seldom keeps well; it is more liable to develop off flavours, and ultimately to become rancid throughout.

When finally made up the butter should present a neat and attractive appearance. Rolls should have perfectly flat (not concave) ends, and a regular cylindrical surface. In a print, the engraved surface should be sharply defined—no ragged edges should appear. (This is a common fault, and often appears when the edges of the die surface becomes worn.) The print should be upstanding (1½ inches high) and not flat. The pattern executed in blocks brings out well the individuality of the maker; it should be distinct and not too deeply impressed on the surface; the corners should be square, and the block should stand up well. A pleasing appearance in the finished article greatly enhances its selling value.

The procedure in judging butter when made up in ½-lb. or 1-lb. lots should follow a regular routine. The appearance, colour, and finish will first be examined and assessed. (This is the easiest part of the business.) The sample will then be cut nearly right across and broken. Immediately the fresh surface is smelt and the aroma determined. The smooth cut surface and the broken edges will be inspected and the texture thus appreciated. A small sample will be squeezed between the fingers to determine the body. Finally a portion of the butter, about the size of a walnut, is placed in the mouth and the flavour tested. The butter should be fully dissolved in the mouth, passed over the palate, and then expectorated. It should not be swallowed.

To correctly judge a large number of show butters and place them in order of merit is a task demanding skill and experience. The country grocer, the general dealer, or even the prize butter-maker seldom has the qualifications required of a good judge.

When examining potted butter, or any butter put up in containers, the testing iron is used to withdraw a sample. The procedure is very similar to that already described. The plug is immediately passed under the nose and the aroma determined.; the plug is held up to the light and the colour examined; the surface is inspected and the texture appreciated; a portion of the plug is broken off and pressed between the fingers and the body tested. Finally the butter is tasted for flavour.

Faults in Butter.

Faults in butter fall under three heads:—(*a*) Faults in flavour; (*b*) faults in body and texture; (*c*) faults in colour (salting).

Apart from any defects in appearance and finish, the more serious faults in butter relate to flavour, texture, and salting. Defective flavours are often closely associated with loose and open texture, and what might have been good-tasting butter often falls into the second grade because of a bad texture, occasioned by a poor grain or faulty working.

The most frequent causes of bad flavours in butter are (1) impure raw material; (2) bad starter; (3) improper ripening; (4) impure washing water; (5) lack of care in keeping utensils (especially the worker) thoroughly clean; (6) food taints.

Butter made from unpasteurised milk or cream, more especially gathered cream, seldom possesses such good keeping properties as butter made from pasteurised cream. But the more perfect the conditions under which the milk is produced the better will be the flavour and keeping properties of the resultant butter. Where whole-milk butter is made it will invariably be found that the prize-winners are those who take more than ordinary care with the milk. This and the use of a good starter, even though it be a butter-milk starter, is the real secret of their success.

Pasteurisation, however, will always improve the condition of the raw material, and, even when the milk has been produced under hygienic conditions, it should invariably be

adopted as a precautionary measure. But pasteurisation has its limits, and while it will undoubtedly get rid of most of the impurities in milk or cream it will not disperse them entirely. The spore-bearing organisms which so often occur in milk carelessly produced are unaffected by ordinary pasteurising temperatures, and it is to the presence of these organisms that bad flavours in butter often arise. It has been shown that pasteurised cream inoculated with gas-producing bacteria produces butter with a bitter, disagreeable, and astringent flavour. Impure raw material may be improved but cannot be completely purified by pasteurisation. Butter made from such material may possess a fairly good initial flavour, but it will not retain it for long.

A bad starter is a common cause of off-flavours in butter. When pure pasteurised cream is used it is the starter more than any other factor which is responsible for flavour. Consequently when the starter becomes contaminated or changes its character (*i.e.*, becomes caseolytic) taints in the butter can scarcely be obviated. With repeated cultivation and exposure to the atmosphere starter soon becomes unsuitable, especially if it is allowed to become consistently over-ripe before being re-inoculated. Sooner or later small bitter-producing cocci, yeasts, and certain putrefactive bacteria make their appearance, and with the emergence of these the starter is no longer fit for use. It is difficult for the dairyman to determine when this deterioration has begun; usually it has developed considerably before it is noticeable. The only guidance he can get is from the senses of smell and taste, and if these be applied daily to determine the flavour of the starter and of the butter, and especially of the buttermilk, a fairly correct estimate of the purity of the starter may be made. Whenever the starter loses its mild acid taste and delicate aroma, or develops even a faint bitterness, it should be immediately rejected.

An unsuitable ripening temperature is largely responsible for much of the bad-flavoured butter that drifts into the market, especially during the cold months of the winter. When the ripening temperature is low the growth of the lactic acid germs is slow, while that of putrefactive bacteria is

relatively rapid. The result is an objectionable aroma and a disagreeable, almost rancid, flavour in the butter. When this condition arises the cream should be carefully pasteurised to 160° F. and inoculated at 80° F, so that even if the temperature does fall considerably during ripening the cream will have thickened before 60° F. is reached. By inducing in this way a quick growth of the lactic acid germs the putrefactive bacteria, even if present, are overgrown and held in suppression.

Raw gathered cream ripened at too low a temperature almost invariably possesses a bad flavour, more especially if no starter is used.

Too high a ripening temperature causes the emergence of gas-producing organisms, which detract from the flavour. The butter has a stale taste, and the odour is not pleasing.

Over-ripening the cream is a common fault, and is of common occurrence in warm summer weather when the atmospheric temperature is high. As soon as the cream has thickened it should be cooled down forthwith to below 50° F. in order to check any further formation of acid. A highly acid cream quickly attracts yeasts and moulds. The resultant butter acquires a sour taste, and does not keep well. To correct any tendency to over-ripening in hot weather the temperature of inoculation of the cream and the temperature of the ripening room should be lowered by several degrees.

The purity of the washing water is a matter of supreme moment. Bad keeping properties in the butter are often due to a contaminated water supply. Water from the surface drainage of fields, shallow well water, and the water from shallow streams is always suspicious. The run-off from roofs is the worst of all. Deep well water and water from a gravitational source are best. Whenever the water is suspicious it should be filtered through an earthenware or carbon filter when relatively small amounts up to 15 gallons daily are required. An effective filter may be made by passing the water through charcoal and quartz sand. The accompanying diagram illustrates a very useful and easily-constructed filter. The depth of the layer of quartz sand should not be less than eighteen inches. This and similar filters should be periodi-

cally cleaned, say once every six months. The charcoal should be taken out and heated to redness in an oven, and the quartz sand boiled for half-an-hour. An ineffective and contaminated

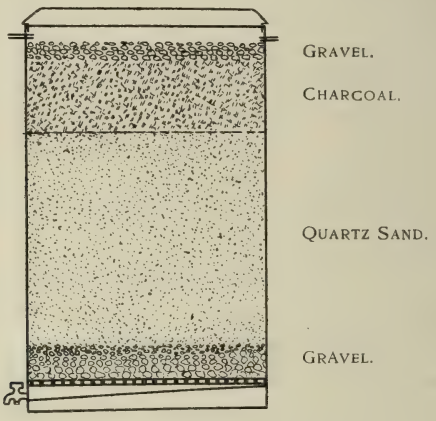

Fig. 22.
Water Filter.

filter is worse than no filter at all. In some cases it may be necessary to boil the water and subsequently cool it for use.

Bacterial contamination in the water can only be detected by a skilled bacteriologist. The dairyman, however, who, after eliminating other sources of error, still finds that the butter does not keep well, may reasonably suspect the purity of the water supply and take measures accordingly.

All utensils are a possible source of contamination in butter-making. In ordinary circumstances the butter-maker may be careful enough about the ripening vessels and the churn, but it is doubtful if sufficient attention is given to the butter-worker. This implement, above all others, must be clean, and cleanliness in this sense means much more than mere tidiness. It means that the bed and roller of the worker should be sterilised before and after use. Unless the wood is hard and close grained it soon begins to wear rough, and a worker in this condition is most difficult to sterilise. After use the worker should be washed and scalded; the washing water may with advantage contain some formalin. Scalding will not only help to sterilise the wood, but it will ensure quick

drying. A damp worker is a suitable habitation for many bad germs which cause off-flavours in butter.

Food taints are of frequent occurrence in farm butter, especially when made from raw cream or milk. In autumn, when the cows are pastured on the "foggage" or aftermath, the milk and cream has often a strong clovery taint. Certain weeds when eaten by the cow tend to give an undesirable flavour, *i.e.*, garlic-mustard and water parsnip; the worst of all is wild garlic. Turnips, rape, or cabbage, fed just before milking, impart a turnippy flavour to milk. This is more likely to happen if the turnips have secondary growths on the crowns after being topped, and especially if they are slightly decayed. Cabbages are particularly bad in this respect. Roots should be fed after milking. But a turnippy flavour is often got in butter when no turnips or other similar roots are being fed to the cows. In this case the undesirable flavour is due to action of certain bacteria, *e.g.*, *Actinomyces odifer*, *B. fluorescens*, *B. subtilis*.

The remedy for this, and, indeed, for all food flavours is effective pasteurisation and the ripening of the cream at a suitable temperature with a good, vigorous starter. In the case of whole-milk butter-making, where pasteurisation is not practised, special care must be devoted to the production of the milk. The addition of 8 per cent. of a vigorous starter is, of course, essential.

Rancidity.—This is perhaps the commonest and worst fault of all in butter. When an appreciable degree of rancidity has developed, the butter is practically unfit for consumption. Though practically any sample of butter will, on exposure, ultimately become rancid, yet the rate at which rancidity develops is largely dependent on the purity of the cream and starter, the degree of cleanliness observed during the process of manufacture, the rate of salting, and the method of packing and storage.

Rancidity is normally a result of two distinct actions, chemical and biological. When a sample of butter is exposed to light and air for any considerable time, it will be observed to undergo a sequence of more or less distinct changes. The first observable change is the disappearance of colour and

flavour. This process starts at the outer surface and works gradually right through the mass. The butter becomes tallowy in taste and appearance. This change is due to an exidation process, and is mainly of a chemical nature; it is accelerated by the contact of sour or ripened cream with rusty utensils or tinned copper vessels, the copper of which has become exposed by wear. The odour and taste resulting from oxidation, however, do not constitute rancidity as generally understood.

This oxidation process is favourable to the second distinct change which is brought about by the action of bacteria, bacterial enzymes, and moulds. These agents effect a splitting of the fat into fatty acid and glycerine, and it is to the production of these free fatty acids that the rancid taste of altered butter is due. Among the bacteria which are capable of hydrolysing the fat are *B. fluorescens liquefacians*, *B. prodigiosus*, *B. aerogenes*; among the moulds, *Cladosporium butyri*, *Oidium lactis*, *Penicillium glaucum*, *Alternaria* sp.

The term "rancidity," however, is often used to denote any bad flavour in butter, accompanied by an unpleasing aroma. In this sense, butter is sometimes "rancid" just after it is made. The off-flavour in this case is due either to bacteria of the *coli* group—the presence of which indicates fecal contamination—or to the appearance of putrefactive ferments which flourish at low temperatures. Unpasteurised cream ripened at low temperatures invariably gives a "tangy" flavour. The remedy in both cases is effective pasteurisation, and the ripening of the cream with a good starter at a suitable temperature, 60°-70° F.

It is difficult to remove a rancid flavour from butter once it has developed, and generally speaking, it is not worth while attempting to do so. Rancid butter, which is edible with difficulty, may be used for cooking purposes. If the rancidity has made any considerable advance, the following procedure may be tried. The affected butter is melted and thoroughly agitated in several changes of warm water at a temperature of 170° F., the melted fat after each washing being allowed to rise to the top and the wash water removed from below. A little hot lime-water may be used in the last washing. When

all the rancid products have thus been removed, the clear fat which should now be practically tasteless is thoroughly switched into warm separated milk—previously pasteurised—and the cream so formed ripened in the usual way.

Faults in Body and Texture.

Weakness in texture is, perhaps, the commonest fault in farm butter in the summer time. At shows and competitions it is very often the texture which determines the award. Indeed, the texture of the butter is an index of the skill of the maker. It is texture which determines very largely the stability of the butter.

A loose, open texture not only makes the butter unduly soft, but it is a constant menace to the flavour and keeping qualities. Butter containing a large amount of free moisture (and consequently of butter-milk), even though heavily salted, quickly goes off flavour, is more liable to develop mouldiness, and to become rancid. In defective texture is to be found the reason for the origin of many undesirable flavours quite foreign to the milk or cream from which the butter was prepared.

Defective texture may arise from several causes—(*a*) too high a ripening temperature; (*b*) want of hardening the cream preparatory to churning; (*c*) too high a churning temperature; (*d*) flaky or uneven grain or lumps; (*e*) too high a temperature of the wash water; and (*f*) faulty manipulation on the worker.

When the butter, on removal from the churn, appears too soft, it should be given a turn on the worker to expel some of the loose moisture and to consolidate it. After bringing the mass together with the hands, it is wrapped in wet muslin and set aside in a cool place to harden before completing working.

Certain foods tend to give a soft-textured-butter—*e.g.*, maize, soya cake, linseed cake, bran, paisley meal, and dried grains. Others give a firm butter—*e.g.*, cotton cake, earth-nut cake, palm-nut cake, and dry fodder. When the butter fat has a natural tendency to be soft, the latter concentrates will be employed; on the other hand, when the butter-fat is

hard, *i.e.*, when the cows are stall-fed, the former foods will be relied on.

Defects in Colour and Salting.

The colour of the butter should be even and of a uniform shade throughout the year. This implies the employment of artificial colouring for nearly two-thirds of the year, because the natural colour of butter from stall-fed cows is too white for the demands of the market. When annatto is employed, sufficient only should be added to approximate the colour of June butter—a pale-straw shade. Too high a colour—which follows the use of too much annatto—is almost as objectionable as a dead-white butter.

The colour may become bleached by exposure to light; this is a direct result of the oxidation of the natural pigments of the butter fat.

Salt deepens the natural colour of butter, but, unless it is thoroughly and evenly dissolved throughout the mass, streakiness or mottles will almost certainly appear. The butter presents a marbled appearance, which, to the consumer, suggests something radically wrong.

The causes of mottling are the presence of too much butter-milk in the butter; the use of impure salt; or uneven distribution of the salt. Butter salted in the brine does not show mottles. If butter has to be dry-salted, an even and uniform grain should always be striven for, because it is only in such a condition that the butter can be washed free of adhering buttermilk. Washing must also be well done, in not less than two changes of water.

Recent Developments in Butter-making.

The process of butter-making as outlined in this *Bulletin* refers more particularly to the manufacture of fresh butter on the farm. With slight modifications as to technique, it is the method which has been so successfully followed in the past in the making of butter on a commercial scale. Within recent years, however, the manufacture of creamery or factory butter has undergone progressive changes, especially with

reference to the temperature of pasteurising and the degree of acidity developed in the cream before churning. High pasteurising temperatures associated with the holding method are now favoured: a common standard is 170°-180° F. for ten minutes. This method not only ensures a more complete destruction of bacteria; it effectively destroys certain milk enzymes — especially peroxidase — the incidence of which is believed to bring about the degradation of the butter during storage. At any rate, as a result of the increased temperature of pasteurisation, the keeping properties of the butter are greatly enhanced. This is especially the case when the cream at churning is relatively sweet. Some factories do not ripen the cream at all. After pasteurisation the cream is chilled to harden the fat, and then churned direct or just prior to churning mixed with 10-20 per cent. carefully prepared starter. Others, again, add starter, ripen at a temperature of 60°-65° F. for six to eight hours, until from 0·25 per cent. to 0·3 per cent. acidity has been developed. A higher acidity is believed to detract from the keeping properties of the butter when stored, and to encourage the growth of yeasts and moulds, which ultimately induce rancidity.

By kind permission of the publishers (Messrs. Blackie & Son, Ltd.), Fig. 2, Fig. 2A, and Fig. 10 are taken from "Milk Supply," by Macewen, and Fig. 7 from the "Standard Cyclopedia of Modern Agriculture."

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Ready for Churning.

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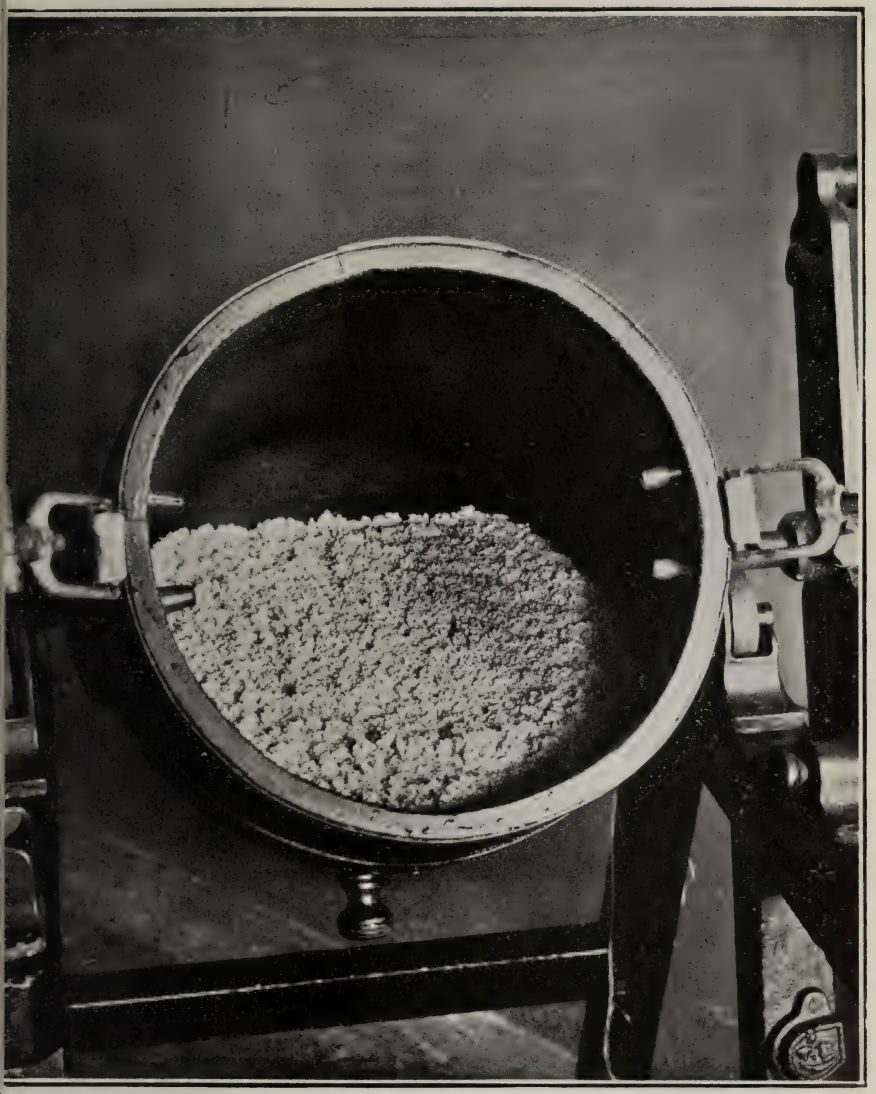

Churning completed—Granular Butter floating in Brine.

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Granular Butter on the Worker.

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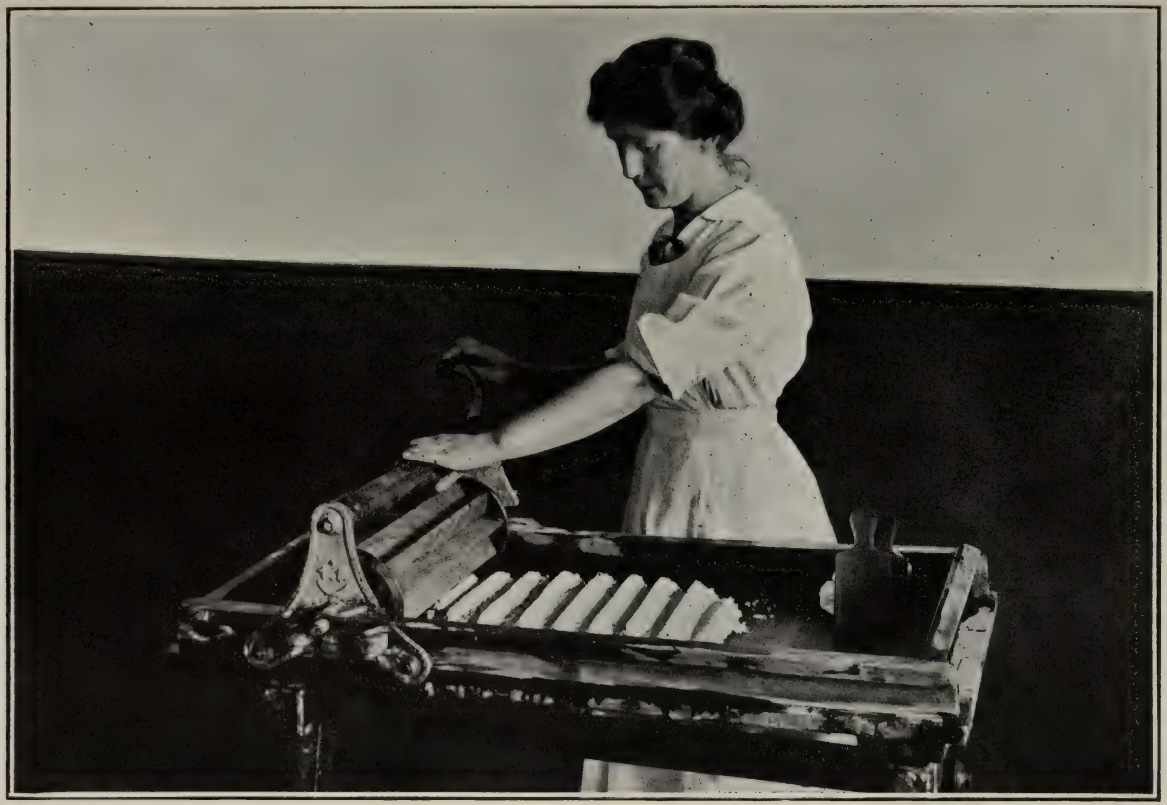

Working the Butter.

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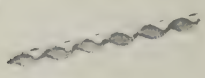

Impressing Design on Butter-block.

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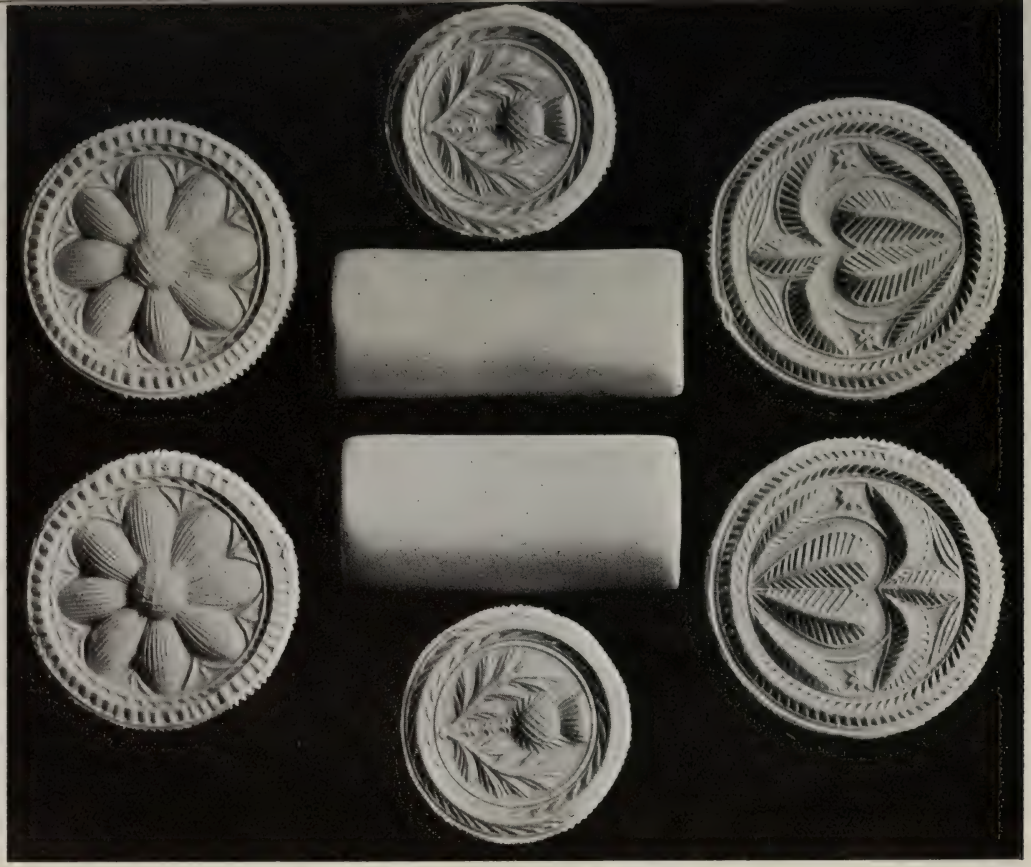

Butter Prints and Rolls.

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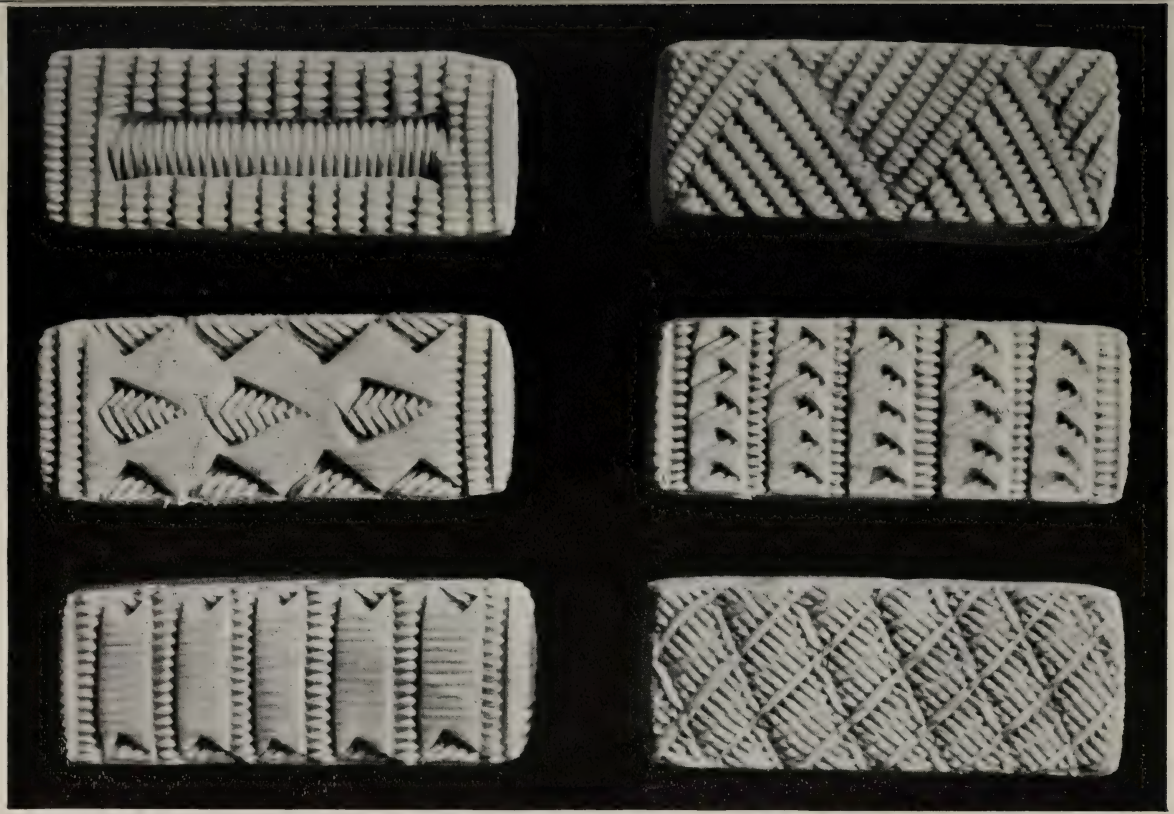

Designs impressed on Blocks. (Plate I.).

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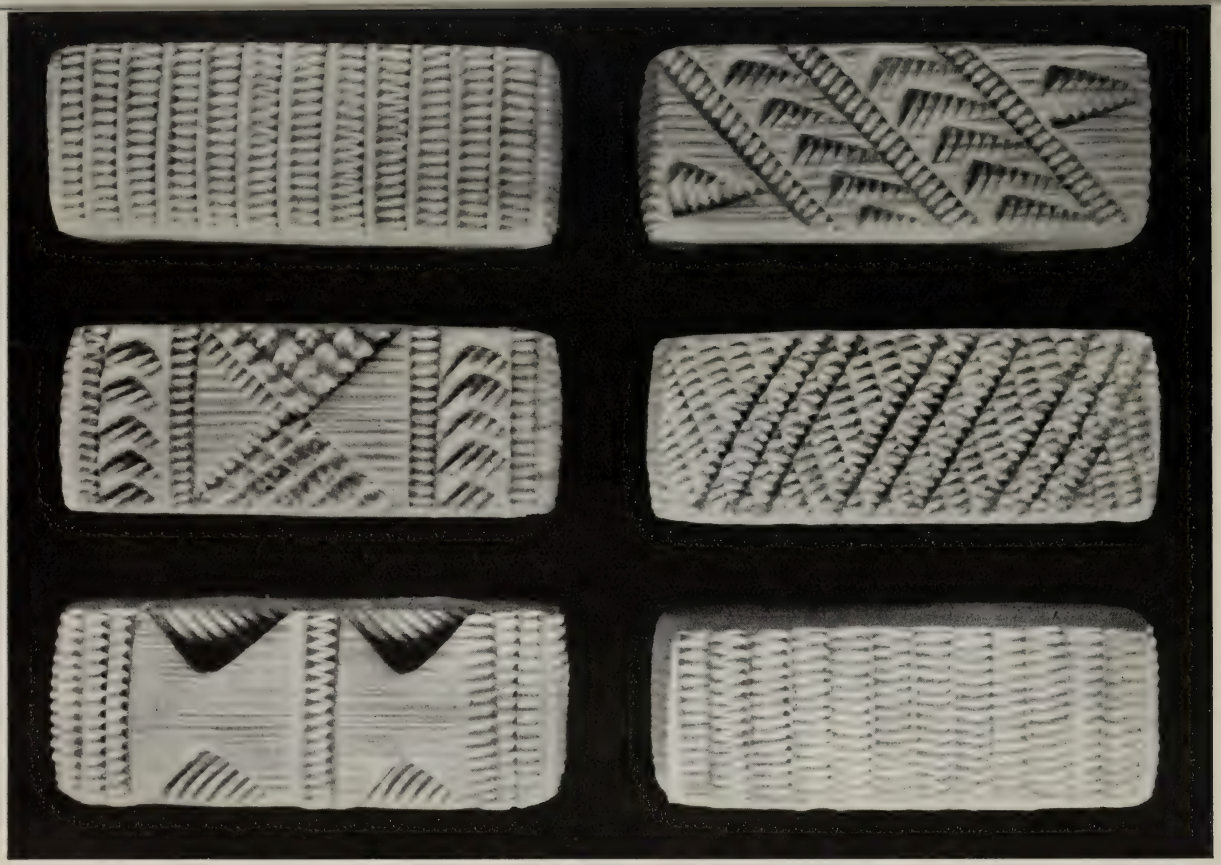

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